852
DISK STORAGE
EQUIPMENT

TRAINING MANUAL
Test Edition

CONTROL DATA INSTITUTE CONTROL DATA CORPORATION

DISK STORAGE EQUIPMENT

FOR TRAINING PURPOSES ONLY

This manual was compiled and
written by members of the
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DISK/DRUM SYSTEMS

CHAPTER I

DISK/DRUM INTRODUCTION

CHAPTER I

DISK/DRUM INTRODUCTION

STORAGE REQUIREMENTS

One of the most important requirements of a Data Processing System is Data Storage. The concept of the modern general purpose computer depends on the availability of a unit to store the program of instructions, and, just as important, large amounts of data. Although its major application is in computers, due to the increasing use of digital methods in other fields, the need for digital data storage is becoming widespread. One important application outside the computing field is in the electronic telephone exchange. The results of many scientific experiments are stored in digital form for later processing by a computer. The explosive rate at which technical information is now being generated has led to an increasing interest in the development of high speed, random access, information retrieval systems. The digital computer will have an important part in this system, but the computer will necessarily depend on the availability of mass random access storage.

The following discussion will deal with auxiliary storage in digital computer applications.

Some of the parameters of auxiliary storage which affect its application are erasability, accessibility, capacity, access time, transfer rate, and of course, cost. If we look at these parameters a little more closely we will see:

1. Erasability is the ability to erase and re-use the memory. Memory, which cannot be erased can be used as permanent record. An example of this type of memory is the punched card. If the application of memory requires that the data be updated, obviously we must first erase the old data before we can insert the new data. This leads us to the next Parameter.

2. Accessibility indicates the ability to store data in a unique location and to retrieve the data from that location. It also indicates the size of the smallest block of data which can be stored or retrieved. In the first property of Accessibility, the unique location, is generally termed the Address. In the second property, the smallest block of data is termed Character, Byte, Word, or Record, depending on its relation to the computer.

3. Capacity involves the total number of Binary Bits which can be stored in the Storage Unit. This is generally given in terms of N Bits, N Characters, or N Words.

4. Access Time is the time involved in storing or retrieving data from a particular address. The time is given in terms of maximum

time, minimum time, and average time.

5. Transfer Rate is the time involved in storing or retrieving data from successive addresses. This is given in terms of Bits per second, Characters per second, or Words per second.

6. Cost can be given in manufacturing cost, maintenance cost, or sale cost. Sales cost can be broken down to the cost of dollars per Bit or in a more comprehensive formula using Capacity, Access Time, and Transfer Rate. This general formula would be

$$\frac{\$ \text{ X Access Time}}{\text{Capacity X Transfer Rate}}$$

The intention of this manual is to cover these Parameters in general terms for various Magnetic Disk and Drum Storage devices, and to cover in detail a particular Disk Storage System: The Control Data 852/3232 Disk Pack System.

THE HISTORY OF MAGNETIC RECORDING

EARLY EFFORTS

Although the use of magnetic recordings in data processing is relatively new, the basic concept of recording information via a magnetic medium has been a reality for more than half a century.

This concept was originally explored by Valdemar Poulsen, a Danish telephone engineer. Poulsen, often referred to as the "Danish Edison", constructed an operational magnetic recording device in 1893. He improved upon this machine, which he called the "Telegraphone", and received the first patent issued for a magnetic recording device in 1898. Though crude by modern standards, his device received the Grand Prix at the 1900 Paris Exposition.

Poulsen's machine used a steel piano wire as the storage medium with information encoded crosswise on the wire; however, a difficulty in the use of wire was its tendency to twist and bend as it passed the reproducing head, thereby causing the crosswise recording to go out of alignment. One other serious fault with the machine was the lack of amplification. This resulted in a very weak signal strength even when the quality of recording was acceptable.

The new technique showed great promise in the field of sound recording and reproduction but, due to the lack of sufficient amplification, development toward its full potential did not occur until after the invention of the vacuum tube by Lee DeForest in 1912.

From its inception until the later 1920's, magnetic recording devices were used primarily in laboratories where experiments resulted in changes and minor improvements to Poulsen's machine. Most of these experiments were conducted in Europe, principally in Germany. The recording medium used in these experiments was either steel wire or a steel tape.

Wire dictating machines were manufactured in Germany and met with some success. A company was formed in the United States to market the Telegraphone but American businessmen were reluctant to accept the device and the company soon folded.

At this point in the development stages the need for a more suitable recording medium was apparent. About 1920 the possibility of using a tape coated with a powdered magnetic material was suggested.

In 1927, a German inventor, Karl Pfleumer, began searching for a material to replace steel wire as a recording medium. He explored the feasibility of using a paper or plastic tape coated with a powdered magnetic material. Two German firms, AEG Company (Allgemeine Elektrisitats Gesellschaft) and BASF (Badishe Anilin - and Soda-Fabrikag) collaborated on Pfleumer's work and produced the first practical tape with a magnetic particle coating. The base of this tape was paper with an iron oxide or metallic particle coating. There is some question as to the type of meterial first used as a coating.

As could be expected, this tape was far from perfect. The recording surface of the tape was comparable to a rough grade of sandpaper, and the adhesive material was of such poor quality that when the tape was run on the recording machine the coating would separate from the base material in a fine spray and literally cloud the air.

About 1935, a recorder using this paper tape was exhibited and marketed. This recorder, the "Magneto-phone", was more readily accepted, though it lacked the mechanical qualities of Poulsen's Telegraphone. The deciding factor for its success was the tape which reduced the operating cost from dollars-per-recording minute, as with steel tape, to pennies-per-recording minute.

Magnetic recording activity in the United States was revived when, in 1937, Bell Laboratories developed a high quality recorder, the "Mirrophone", and Brush Development Company produced its "Sound Mirror" recorder. Both of these recorders used a steel tape as a recording medium and the "Sound Mirror" had a recording time of approximately one minute on a loop of tape.

With the world on the brink of war the sharing of technological advances, including magnetic recording, was halted. Both the U. S. and Germany could foresee the requirement for devices capable of quickly and accurately recording information. The Germans naturally took advantage of their past accomplishments and pursued the development of coated tape

while the United States concentrated on steel wire and steel tape. In the late 1930's the Japanese were also exploring the field of magnetic recording.

WAR EFFORTS

As in other areas, World War II added impetus to the experiments being conducted and rapid developments were forthcoming. The Germans, by 1939, had developed a relatively good plastic tape and also a number of good recording machines, including a device with a rotating head and one with a tape speed of 30 inches per second.

In the United States, Brush was experimenting with a paper tape and also a coated wire for recording. Other companies were becoming active in the field and around 1943 Webcor was manufacturing wire recorders for the Navy. Late in 1944 Minnesota Mining and Manufacturing Company untertook experiments in an attempt to develop a recording tape using a ferro-magnetic powder as a coating.

Near the end of the war, an improved version of the German Magnetophone was captured intact and, at the conclusion of the war, the American recording industry reaped the benefits of German research and ingenuity.

From this time steel wire and steel tape, as a recording medium, was replaced with plastic-base tape. Magnetic tape recording became a household term as numerous manufacturers produced home recorders as well as recorders for industrial and business applications.

THEORY OF MAGNETISM

CLASSES OF MAGNETS

Magnets are classified as being natural or artificial according to the manner in which they are formed. The ancient Greeks knew that certain stones found in the town of Magnesia in Asia Minor had the property of attracting bits of iron ore possessing magnetic qualities.

Although useful in the days of the ancient Greeks, magnetite, a natural magnet, has only historical value today. Stronger and more efficient magnets can be produced by artificial means.

An artificial magnet can be formed by placing a bar of iron or steel in a coil of insulated wire and passing a current through the coil as shown in Figure 1-1-1. As the current passes through the coil, magnetic poles are formed as indicated by N representing the North Pole and S the South Pole. The bar is said to be magnetized.

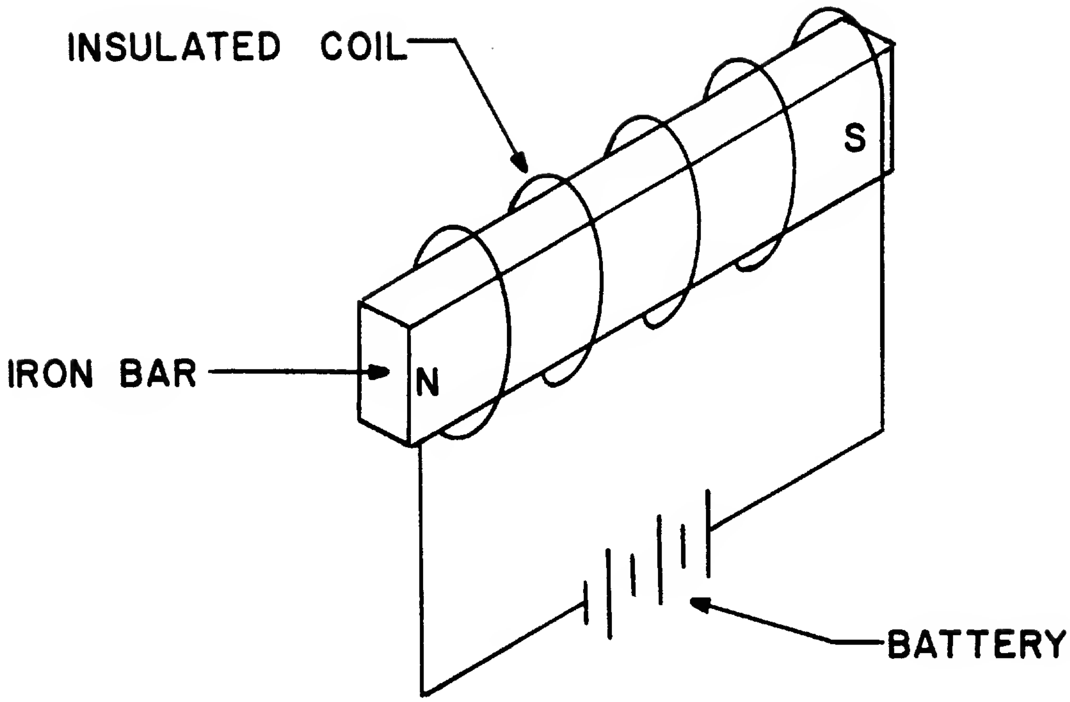


Figure 1-1-1. Forming an Artificial Magnet

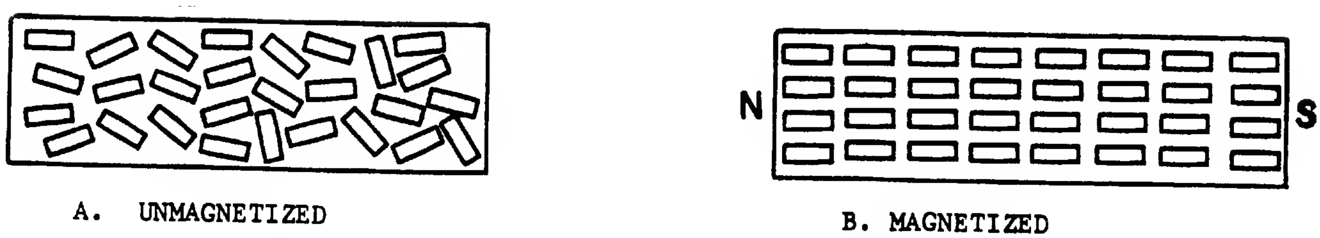


Figure 1-1-2. Molecular Theory of Magnetism

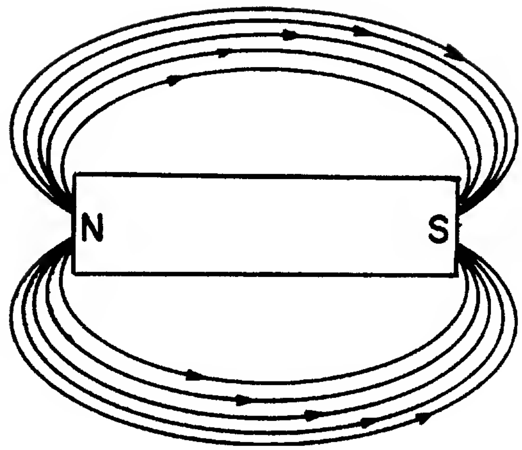


Figure 1-1-3. Magnetic Lines of Force.

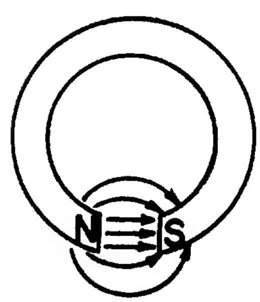


Figure 1-1-4. "Horseshoe" Magnet showing Concentration of Magnetic Field.

The molecular theory of magnetism is illustrated in Figure 1-1-2. Figure 1-1-3A shows a piece of unmagnetized iron where each molecular is considered to be a tiny magnet. These molecular magnets are arranged in a random manner. The magnetism of each of the molecules is neutralized by adjacent molecules and no external magnetic effect is produced. When a magnetizing force is applied to the iron bar, the molecules align themselves so all North Poles (N) point in one direction and all South Poles (S) point in the other direction as shown in Figure 1-1-3B.

TYPES OF ARTIFICIAL MAGNETS

An artificial magnet may be either of two types--"Permanent" or "Temporary"--depending on its ability to retain magnetic strength after the magnetizing force has been removed. Hardened steel and certain alloys are relatively difficult to magnetize and are said to have a low permeability because the magnetic lines of force do not easily permeat, or distribute themselves readily, through the steel. These materials, however, do retain a large part of their magnetic strength and are said to be permanent. This ability of a material to retain its magnetic strength is referred to as the retentivity of the material.

Soft iron has a high permeability and is called a temporary magnet due to the fact that it can retain only a small amount of its magnetic strength when the magnetizing force is removed.

Figure 1-1-3 illustrates a bar magnet and some of the facts that are known about magnets.

MAGNETIC PRINCIPLES

All magnets have two poles, a North Pole (N) and a South Pole (S). A magnetic field exists around the bar magnet. This field consists of imaginary lines along which a magnetic force acts. These lines emerge from the North Pole of the magnet and enter the South Pole, returning to the North pole through the magnet itself and forming closed loops. The entire quantity of magnetic lines surrounding a magnet is called magnetic, while the number of lines per unit area is called flux density.

If a bar magnet is bent to form a loop without the ends touching (as shown in Figure 1-1-4, a magnet will be formed having a magnetic field that is of shorter length and greater concentration than the bar magnet.

One characteristic of the imaginary lines in a magnetic field is that they tend to take the path of least reluctance (magnetic resistance). In other words, they pass through the material that has the greater permeability. Air offers more reluctance to the lines of force than does iron or steel.

If a piece of iron is brought into proximity with the gap of the horseshoe magnet, as shown in Figure 1-1-4, the lines of force will tend to bend so as to pass through the iron. The piece of iron will become magnetized

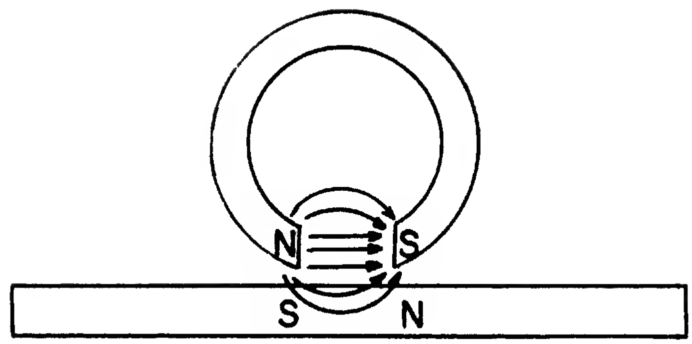


Figure 1-1-5. Lines of Force Inducing Magnetism.

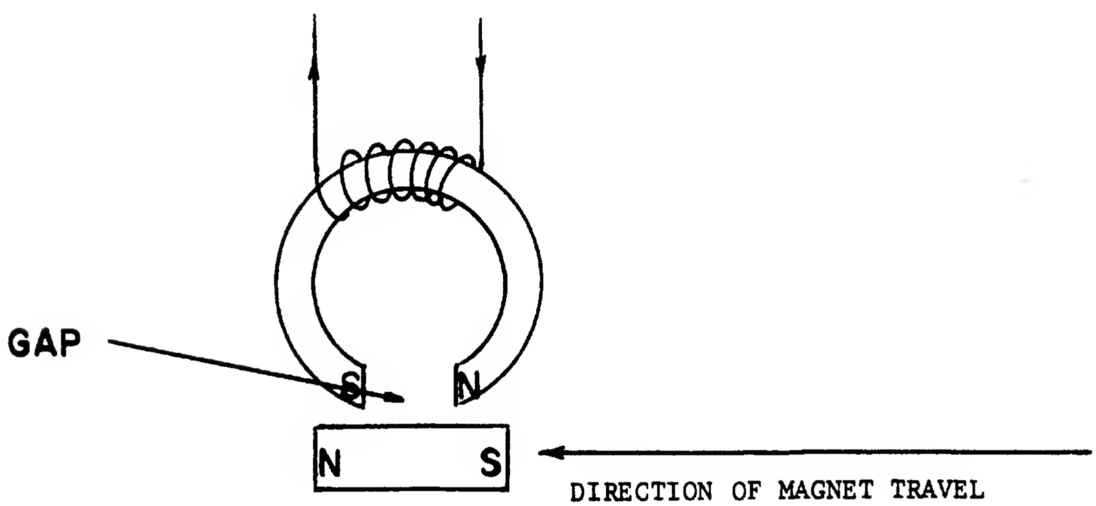


Figure 1-1-6. Inducing Current in a Coil.

by the imaginary lines flowing through it. This characteristic of magnetism, referred to as induction, is utilized in the process of magnetic recording.

THE ELECTROMAGNET

If an electric current flows through a piece of wire, a magnetic field is built up around the current-carrying conductor. Referring again to Figure 1-1-1, when a coil of wire is placed around a piece of iron and a current flows through the coil, the magnetic field of the coil magnetizes the iron bar. A device of this type is called an electromagnet. If the direction of current flow is reversed the polarity of the magnetized core will reverse.

The core of the electromagnet can be in the shape of the horseshoe magnet of Figure 1-1-4. An electromagnet of this configuration is basically the type of device used as a "Write" head in a magnetic tape recorder.

In Figure 1-1-6, an electromagnet is shown with another magnet being passed close to the gap. As the magnet passes, its lines of force will flow through the core of the electromagnet and a current will be induced in the coil. This is basically the idea behind "Reading" information from a magnetic tape.

THEORY OF MAGNETIC RECORDING

SURFACE RECORDING WITH ALTERNATING CURRENTS

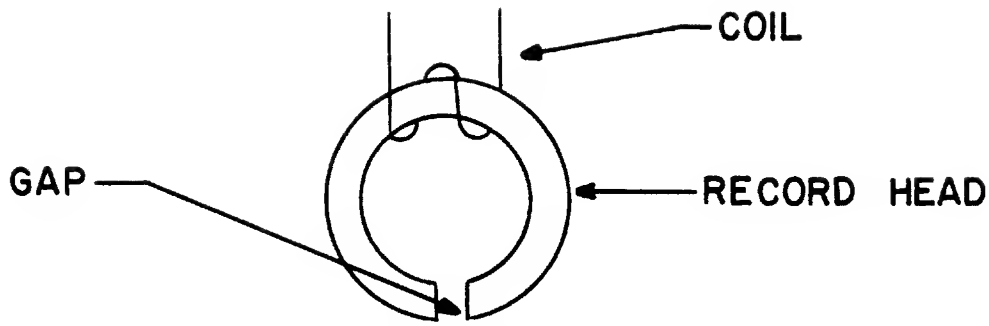
One fundemental method of recording on tape involves the magnetization of minute areas on the surface of a highly retentive magnetic material. In order to reproduce the recorded information, the magnetic state of the material is "Read" back by using the retained or residual flux to induce voltages in the read circuits. This method, commonly called surface recording, is used to record information on magnetic tape.

Magnetic surface recording is based on the interaction between a material, such as magnetic tape and a magnetic head (transducer) in relative motion.

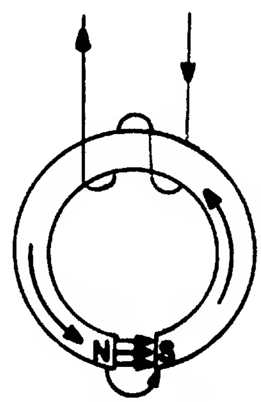
Writing

First we will explore surface recording; the process of "Writing" on a magnetic tape. In order to accomplish this, there must be a basic understanding of the construction of the recording or "White" head.

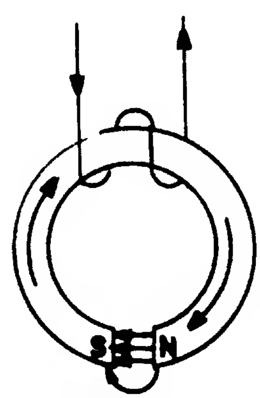
It was pointed out in the section on magnetism that a horseshoe magnet has an air gap through which a magnetic field or magnetic flux is present. This magnetic field is comprised of invisible lines of force that emanate from the North Pole of the magnet and enter the South Pole, making a closed loop.



A. NO CURRENT THROUGH COIL



B. CURRENT THROUGH COIL



C. CURRENT REVERSED

Figure 1-1-7. Simplified Drawing of Recording Head.

The recording or "Write" head used in magnetic tape recording is basically an electromagnet similar to the horseshoe magnet discussed earlier.

Figure 1-1-7A is a simplified drawing of a recording head having no current flowing in the coil and, consequently, no magnetic field. In order to generate a magnetic field, current must flow in the coil, as shown in Figure 1-1-7B. If current is flowing as indicated by the arrows, an electromagnet is formed with North and South Poles and lines of force as indicated. In Figure 1-1-7C, the direction of current flow has been reversed. Note that the poles of the electromagnet reverse with the resultant reversal in the direction of the lines of force.

Based upon the foregoing principles, the events which occur when a magnetic tape is brought into contact with the head can be more easily understood.

The fact has already been pointed out that magnetic tape is constructed of a plastic base coated with a meterial that has the capability of being magnetized and of retaining that state of magnetization for an indefinite period of time.

Figure 1-1-8A shows the recording head with no current flowing in coil; therefore, a magnetic field is not present and no change takes place on the surface of the magnetic tape. In Figure 1-1-8B, the head is shown with current flow and the resulting magnetic field. The magnetic field passes through the surface of the tape and changes the magnetic polarity of a small area. The current direction is reversed in Figure 1-1-8C and, as shown, a different condition exists on the surface of the tape.

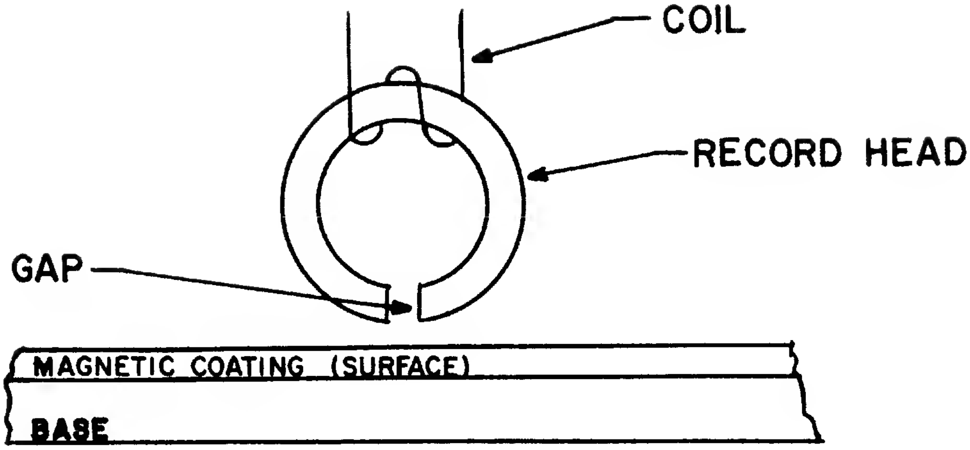
It was previously pointed out that surface recording is dependent on relative motion between the recording head and the tape. Figure 1-1-10A shows the relationship of a fixed recording head with magnetic tape moving in the direction shown. The illustration also shows one cycle of an alternating current and the resulting current flow through the coil. Note that the current flow through the coil reverses with a change from positive to negative direction and the polarity of the recorded information on the tape also reverses.

We have examined only one cycle in the process of recording on tape. This could be continued for any number of cycles with each one establishing two definite areas of magnetized tape of opposite polarity.

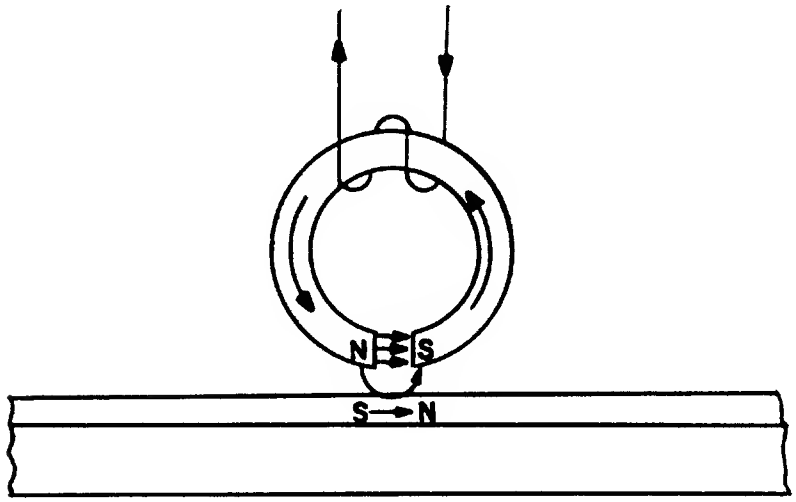
Reading

In the "Read" or reproduce operation a previously recorded tape will move into the vicinity of the read head gap. It should be pointed out that the "Read" head is quite similar in construction to the "write" head.

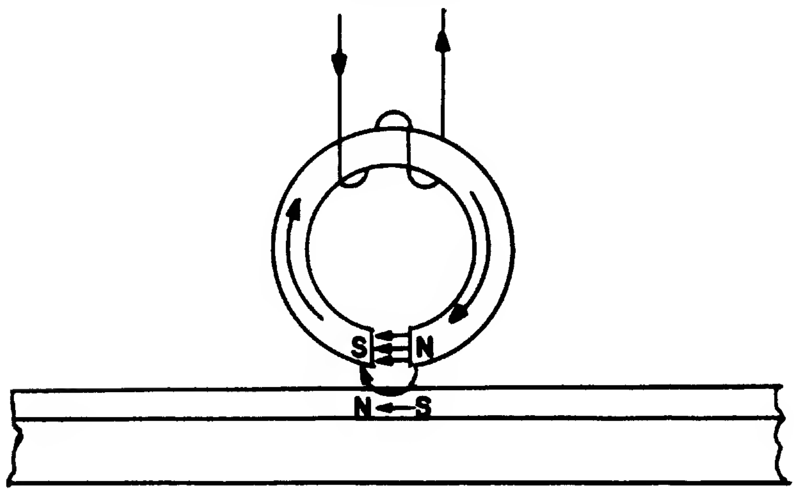
Figure 1-1-B shows a stationary head with the tape being moved in a given direction. In this illustration we are interested in a changing magnetic field associated with one alternation. As the tape passes under



A. NO CURRENT THROUGH COIL



B. CURRENT THROUGH COIL



C. CURRENT REVERSED

Figure 1-1-8. Recording on a Magnetic Surface.

the read head, the changing polarity of the recorded information on tape induces a current in the read head coil. Note that a current is produced in the coil only when the magnetic field on the tape changes. When the information is read from tape it in no way alters the magnetic state of the tape so that a recorded tape can be read an indefinite number of times.

SURFACE RECORDING DIGITAL INFORMATION

In the preceding discussion we have been concerned with an alternating current inducing a change in the magnetic state of the tape. In recording digital information, as encountered with digital computers, we are concerned with recording information represented by pulses which represent the binary states of "1" and "0".

There are numerous schemes for recording digital information but we will consider only the most common one--the one used in Control Data Tape Transports and the Control Data Tape Certifier. This recording scheme is referred to as the Non-Return-TO-Zero, Change on Ones (NEZ) method. This particular method is also designated Non-Return-To-Zero, Indiscrete (NRZI).

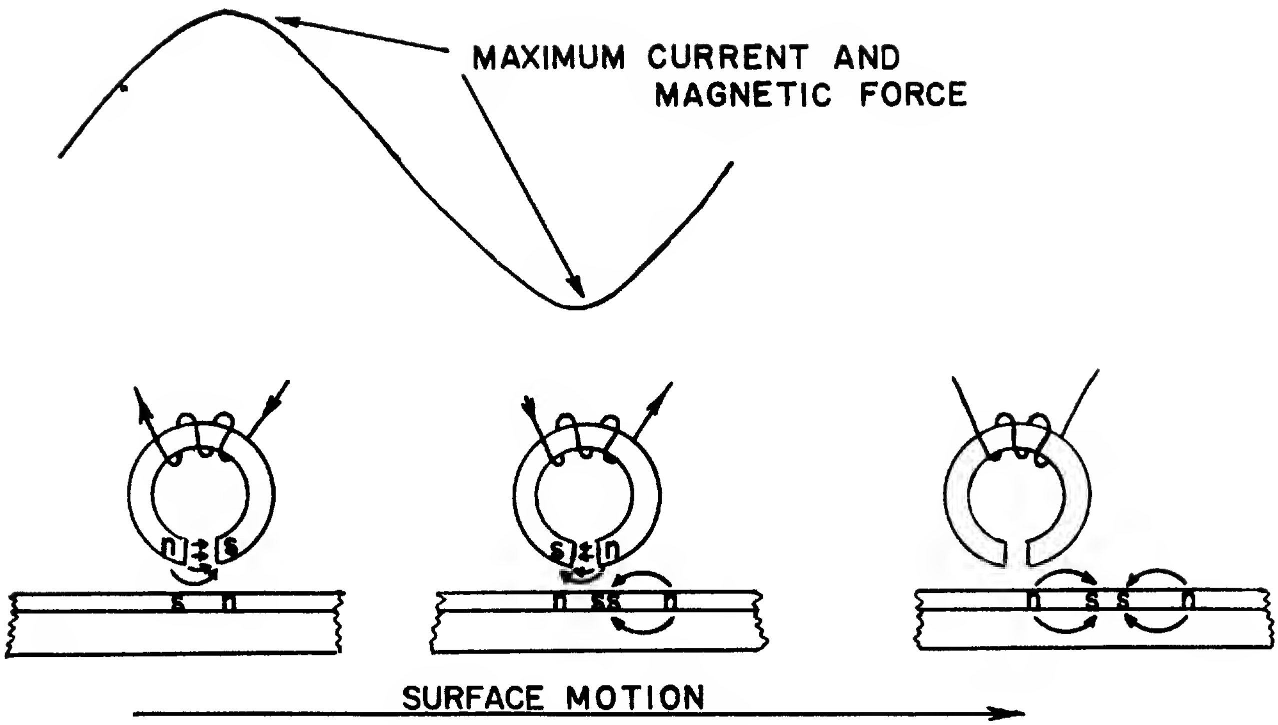
The illustration in Figure 1-1-10 shows the "Write" current applied to the coil of the write head, the flux configuration of the magnetized particles on tape, and the signal developed as the tape is read.

Note that a change in the Write current occurs only when a "1" is to be recorded whereas during the period when "0's" are recorded, the write current remains at the same level. A change in the flux pattern on tape occurs only when the write current changes (a "1" is to be recorded). A change in the flux pattern on tape does not occur if the write current does not change ("0's" are recorded).

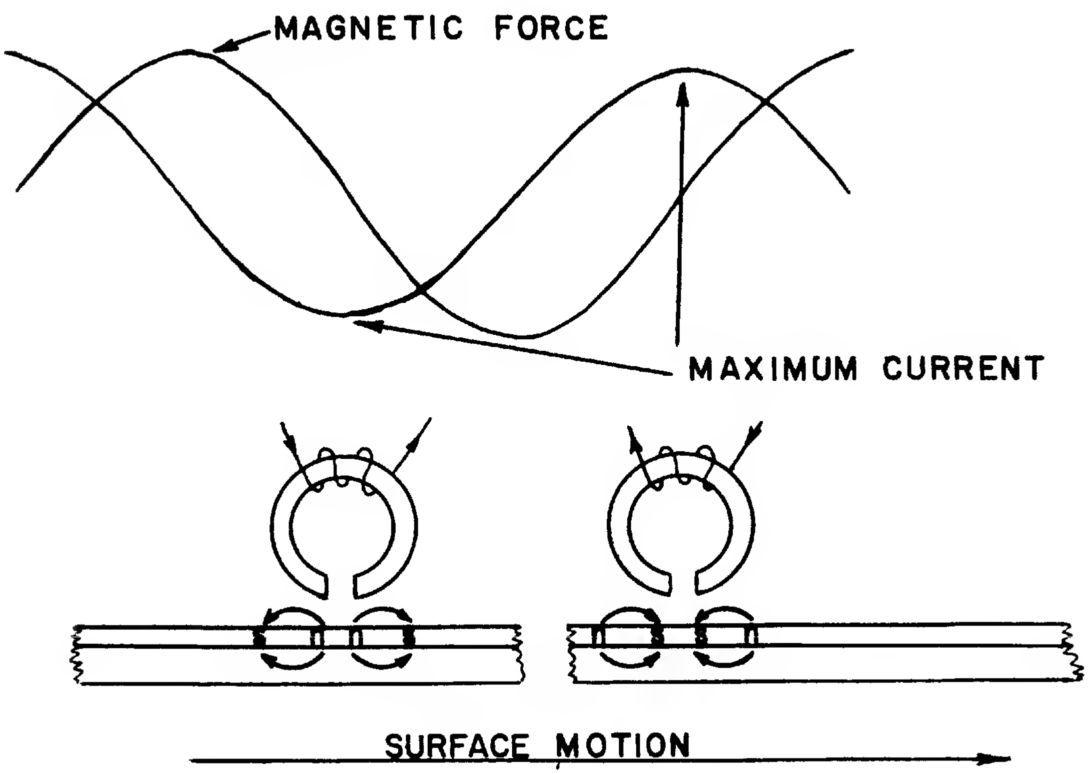
During a read operation, a read signal is produced only when a change in the flux pattern on tape is encountered, signifying that a "1" had been recorded. When a change in the flux pattern is not present, zero's are read.

The material presented in the foregoing is intended to be only a brief description of basic theory of tape recording and one of the recording schemes necessary for a more thorough understanding of tape certification.

For other types of recording, see Appendix A.



A. RECORDING (WRITE OPERATION)



B. REPRODUCING (READ OPERATION)

Figure 1-1-9. Relative Head to Surface Motion.

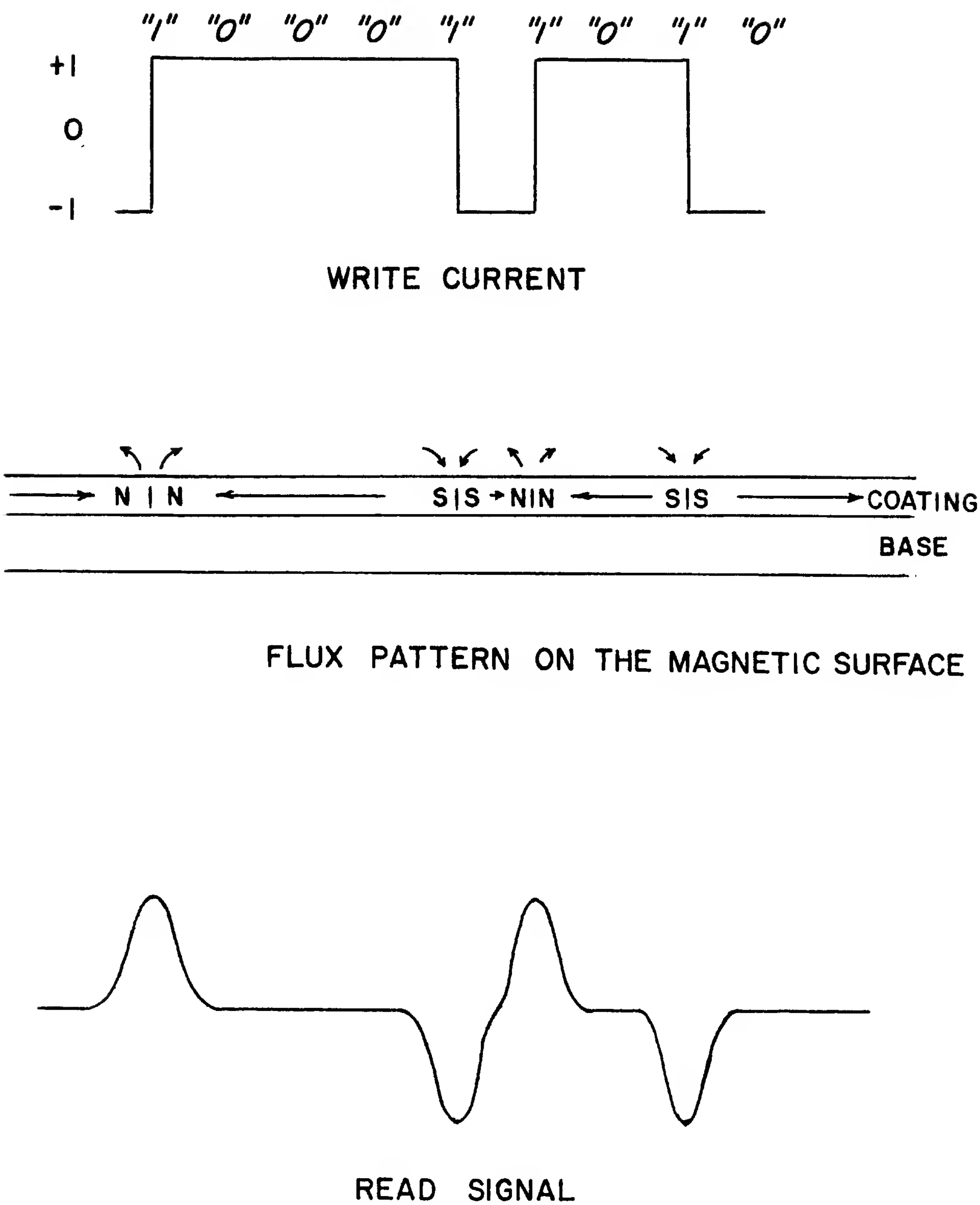


Figure 1-1-10. Non-Return-to-Zero, Change on Ones.

CHAPTER II

PRINCIPLES OF DISK AND DRUM SYSTEMS

CHAPTER II

PRINCIPLES OF DRUM AND DISK SYSTEMS

DRUM SYSTEM

One device upon which a magnetic coating can be placed is a drum. The magnetic material may be iron oxide which is sprayed onto a drum surface, or a nickle alloy (such as nickle-colbalt) which is electroplated unto a drum surface. The size of this drum may vary from several inches in height and diameter, to several feet, depending on the required capacity and access time.

Before we can appreciate the relationship of drum size to capacity and access time, we must look at the organization of the data which is stored on the drum. As previously stated, magnetic surface recording depends on relative motion between the record head and the recording surface. To obtain this relative motion in a drum system, the drum is rotated about its cylindrical axis and the head fixed in close proximity to the drum surface. It can be seen that the data is stored in a ring track around the surface of the drum, and, therefore, the larger the diameter, the more data that can be stored. Now we can add heads to record additional tracks. The number of heads which can be added is dependent on the height of the drum. We can now have some appreciation for the relationship between physical size and capacity of the drum unit.

Access time, on the other hand, is only indirectly related to physical size.

Maximum access time of a drum unit is equal to the time it takes for one complete drum revolution. That is, a complete drum revolution may be required before a particular bit of data passes under the record head. Therefore, access tlme os directly related to drum rotational speed, however, maximum rotational speed is limited by centrifugal force and other mechanical limitations directly related to physical drum diameter.

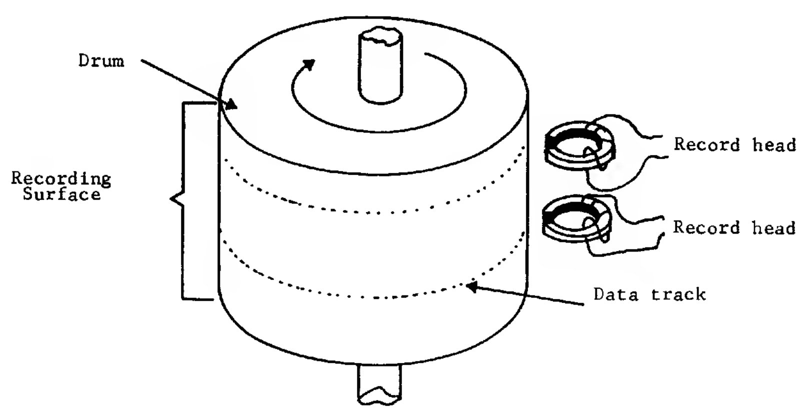


Figure 1-2-1

The obvious advantage of a drum system is its simplicity. There is only one moving part, the drum itself. Another advantage, and a very important advantage, is the low access time. Some standard production drum systems rotate the drum at 12,000 RPM, giving a maximum access time of only 5 milliseconds.

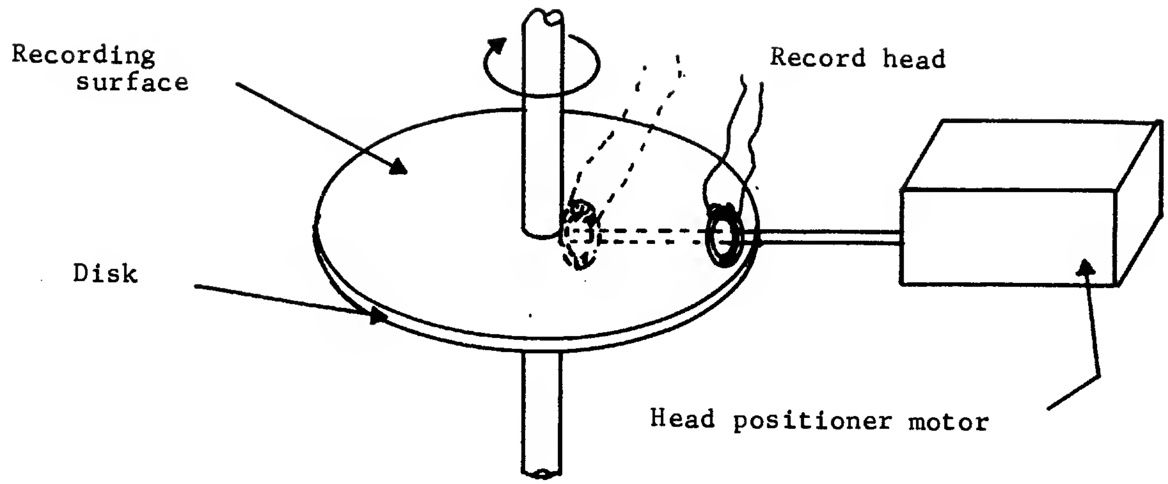
DISK SYSTEM

Another device upon which we can apply a magnetic surface is the disk. The magnetic coating used on a disk is generally iron oxide. Disks vary in diameter from about 10 inches to 36 inches, again depending on the required capacity and access time. The relationship of physical size to capacity and access time seems to be the same for the disk as it was for the drum, however, there are also distinct differences.

Let us again look at the data organization, this time for the disk. As with the drum, the relative surface-to-head motion is obtained by moving the surface (the disk). The disk is rotated about its cylindrical axis and the head is held in close proximity to the flat surface of the disk. The data is stored in concentric tracks on the surface and the number of tracks depends on the diameter of the disk. Notice that the diameters of the tracks also change. The outermost track has a much greater diameter than the innermost track. There is room for more data in the outermost track than there is in the innermost track. However, it requires a very sophisticated system to utilize this fact.

Remember that the rotational speed of the disk is fixed, that is, it takes a given amount of time for one complete disk revolution. To read the larger amount of data in the outer track in the same given time as the lesser amount in the inner track would require that the outer track be read at a higher transfer rate. On the other hand, if the amount of data in the outer track is held to the same amount of data as the inner track, there is a loss of efficiency. There are production systems using both methods and some which use an optimized combination of both methods.

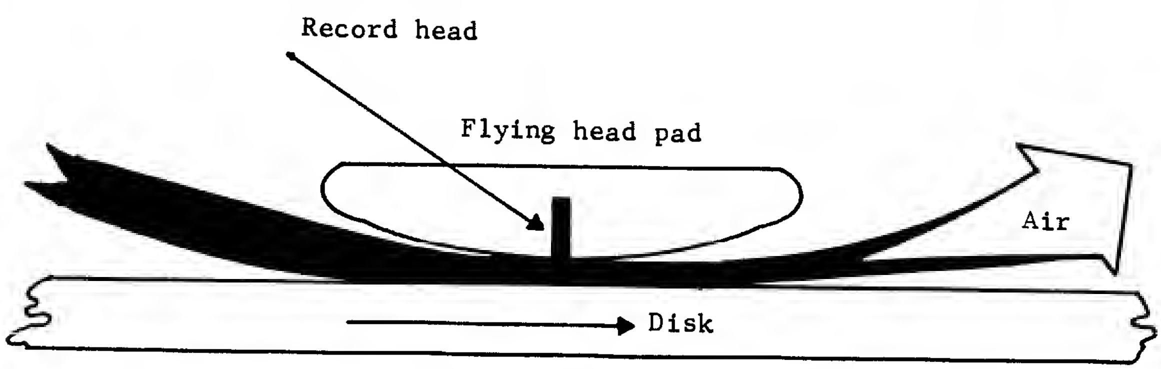
One aspect of access time remains the same for the disk as for the drum. That is the speed of revolution. However, an additional variable affects the access time of a disk. A drum system will generally have one head per track. A disk system, though, may have only one head for an entire disk surface having many tracks. Additional mechanics are required to move the head to each separate track. The time involved in moving the head to the desired track must be included in the access time.



The advantage of the disk system is the high packing density that can be achieved. Many disks can be stacked on the same shaft with only a small gap between each disk to allow the record head to enter. Also the top and the bottom surfaces may be used.

FLYING HEAD

The last principle which is common to most disk and drum systems is the flying head. When disk systems are manufactured they are dynamically balanced and aligned for minimum run-out. This is necessary to maintain a constant gap between the record head and the disk surface. However, perfection is extremely costly. A method which can maintain a fairly constant gap, even though there is some wobble and run-out of the disk,



is the pressure-loaded flying head. The record head is mounted in a pad which is large enough to fly on the film of air which rotates with the disk. At the same time, a spring (or outside air pressure) is forced against the top of the pad. With proper balancing of the lift of the pad and downward pressure, an almost perfect gap can be obtained. If the disk wobbles up and down, the pad will follow the disk and maintain a constant gap.

POSITIONING SYSTEMS

Although different recording techniques are used to record data, all disk storage systems record on concentric tracks on the disk surface. Track spacing and width will vary in different systems, but those using a demountable disk pack (such as the Control Data® 852 Disk Drive) must all be identical to insure compatibility among units. It can be seen that any given track location must be accurately accessible by all units employing the disk packs and this function must be performed by the positioning system driving the carriage to which the Read/Write heads are mounted.

Since random access of data is one of the outstanding features of a disk storage system and fast access a requirement, positioner velocity must approach the maximum possible (depending on inertial loads) and still retain the necessary degree of accuracy. In most systems, a positioner move command is resolved into the distance between the R/W heads present position and the ordered position--track spacing and width being accurately defined in a given system. This distance is usually received at the disk drive as a binary coded number indicating the number of tracks to be traversed. The number must be decoded and cause the positioner to make the ordered move. Matrix and incremental decoding are the two basic modes used in this regard.

MATRIX DECODING

Matrix decoding usually converts the binary coded number, to a signal in the form of a voltage level, utilizing some form of digital-to-analog conversion. This signal accurately represents a given position within the operating limits of the positioner. The positioner's present position is also measured as a voltage level within the same limits(generally by an inductive transducer). The two signals are summed or algebraically added in a summing network and the resulting voltage difference is applied to the positioner drive system as an error voltage. Movement will be initiated and the positioner will drive so as to reduce the error voltage. The positioner location sensing device will detect the positioner's location by a changing signal or voltage level. The error voltage will proportionally reduce. When the difference between positioner location and ordered signal is zero (as detected by a zero error voltage) ordered location of the positioner has been reached.

Various feedback and damping circuits are used to insure extreme accuracy and to control acceleration and velocity. During positioner movement, error voltage alone is considered and actual track count is not maintained nor utilized. Most systems employing hydraulic power in positioner movement use the matrix decoding system.

INCREMENTAL DECODING

Incremental decoding systems read the binary coded number as the distance to move usually as number of tracks. Positioner mechanics must include a means of detecting each track traversed. This is usually accomplished by photo-electric reading of a timing disk and mask assembly. Such mechanics and circuitry are also adopted to determine velocity of carriage movement.

Carriage motion is initiated in a programmed direction to reduce the number of tracks to be passed. Improper programming can cause carriage movement in the opposite direction resulting in a fault condition.

Carriage velocity is usually a function of the size of the ordered signal, and the programmed type of move. Actual velocity is detected by the timing disk assembly and circuitry, and control voltages are applied representing the number of tracks to be passed to reach the ordered position.

Carriage movement is a function of the number of tracks passed, as read by the photo-electric system. Each track passed will cause a decrement signal to a counter originally loaded with the move order. The positioner being at the ordered location is indicated by the counter containing zero and a stop signal is initiated.

When not moving, the positioner is locked by an electro-magnetically operated detent mechanism. Incremental decoding is used in the CDC 852 Disk Drive and most other systems employing an electric motor as a means of positioner power.

SECTION II

CONTROL DATA 852 DISK DRIVE SYSTEM

CHAPTER I

CONTROL DATA 852 DISK DRIVE INTRODUCTION

852   Disk Storage Drive

CHAPTER I

852 INTRODUCTION

SPECIFICATIONS

The 852 Disk Drive System is a medium access time, nonvolatile, memory storage system. The subsystem provides large volume data storage with random access and interchangeable storage pack capabilities. The 3232 controller provides the interface between the 852 disk drive and a 3000 data channel.

TABLE 2-1-1. EQUIPMENT SPECIFICATIONS

CHARACTERISTIC	SPECIFICATIONS
CAPACITY/DATA FORMAT	
Total Capacity	2,000,000 characters (Sector Mode) 2,980,000 characters (Full-Track Mode)
Bits per Character/Byte	7 bits (BCD) plus 2 sync bits
Characters per Disk Surface	2,000,000
Characters per Track	2,000
PROCESSING SPEED	
Access Time (maximum)	145 milliseconds
Track-to-track Access Time	30 milliseconds
Latency Time (maximum)	40 milliseconds
RECORDING	
Mode	(NRZI) Non-Return to Zero Indiscrete
Density	684 bpi (outer track) 988 bpi (inner track)
Bit Rate	699.53 KC
Data Transfer Rate	77,730 characters/sec
DISKS	
Number of Disks	6
Usable Disk Surfaces	10
Tracks per Disk Surface	100
Speed	1500 rpm
Diameter	14 inches
Coating	Magnetic Oxide
HEADS	
Total	10
Read/Write Width	0.010 inch
Erase Width	0.018 inch
Track Spacing	0.020 inch
ADDRESSING	IBM Compatible
OPERATOR CONTROLS	Unit number indicator Start switch/indicator Fault switch/indicator

TABLE 2-1-2. DETAILED SPECIFICATIONS

CHARACTERISTIC	SPECIFICATION
ELECTRICAL	
Power Source	208 volt, 50/60 cycle, 3-phase
Maximum Current	3 amperes/phase
Power Connector	One male connector (5 pole, 20 amp,Hubble Twistlock No. 3521) on short cord for connection inside cabinet to an exten-cord type female connector, or under the floor to a conduit post mounted receptacle.
Pole Assignments	X-phase 1 N -Neutral Y-phase 2 Grd - chassis ground Z-phase 3
Input/Output Connectors	Two female connectors located on the input/out panel. Pin assignments according to table 1-3.
PHYSICAL	
Height	40-3/4 inches
Depth	36 inches
Width	24 inches
Weight	480 pounds
Environment	
Operating	60°-90° F (20°F/hr. -max. gradient) 10%-80% relative humidity
Non-operating	-30° to 150° F 5-98 % relative humidity
Heat Dissipation	3000 BTU/HR

DISK PACK

MECHANICAL DESCRIPTION

The disk pack is a removable, light, compact unit comprising six disks. The disks are 14 inches in diameter and are mounted 0.4 inches apart on a common vertical shaft. The shaft and disks are assembled as an integral unit that is easily removed from the drive unit. Protective plates are provided above and below the recording surfaces of the disk pack to prevent accidental damage to the recording surface. The upper protective plate consists of a standard disk mounted on thecommon shaft directly above the top data disk.

The bottom protective plate consists of a black anodized, 14 and 1/2-inch disk, mounted on the common shaft, directly below the bottom data disk, (Figure 2-1-2). The bottom protective disk contains 21 notches which are sensed photoelectrically to indicate index and sector. The disk pack provides ten surfaces for recording data; the outer top and bottom surfaces are not used because of the protective plates. The disk pack is housed in a plastic container for dust-free storage. The plastic container is automatically removed when the disk pack is installed in the disk drive.

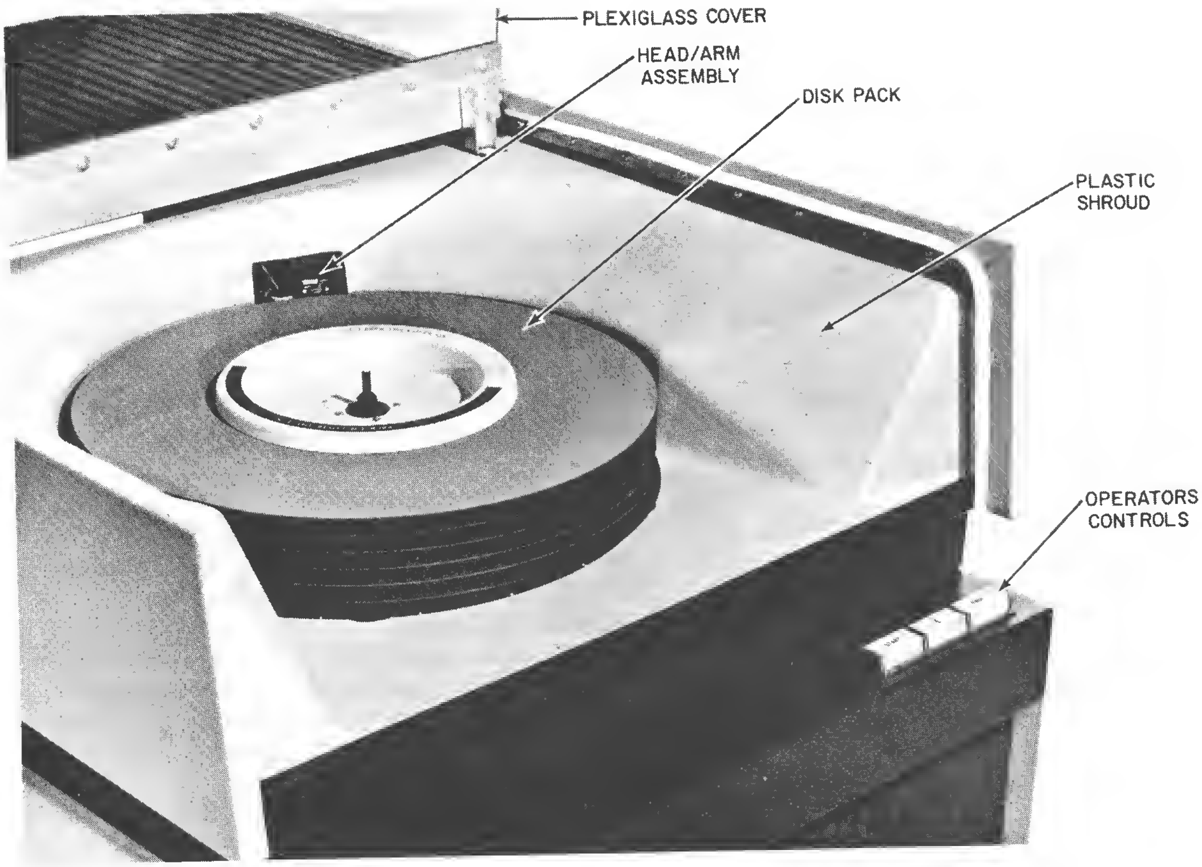
SECTOR, TRACK, AND CYLINDER ORGANIZATION

The disk pack contains ten recording surfaces. Each surface contains 100 tracks and each track is further divided into 20 sectors, (Figure 2-1-3A). A sector is the smallest portion of data that can be randomly accessed. Each sector is designated by a unique address to facilitate accessing. The addressing format is cylindrical to provide the maximum amount of data for each position of the heads (Figure 2-1-3B).

RECORD FORMAT

Sector Record

A sector record contains 1329 data cells (Figure 2-1-4A). The first 180 cells contain all "1's" and are used by the read circuits to establish the gain of the amplifiers (automatic gain control). A five-cell gap ("0's") follows the AGC to separate the AGC from the data. The first block of data, 54 cells, contains the sector address. The address is followed by another five-cell gap for separation. Following this second gap are 100 cells of all ones to provide AGC for the data. Another five-cell gap separates the data. Following the third gap are 900 cells of data. Finally, the 80-cell gap between the data and the following sector provides a buffer which will allow the data block to vary slightly in length without interfering with the following sector. The 80-cell gap is an approximate figure.



Disk Storage Drive

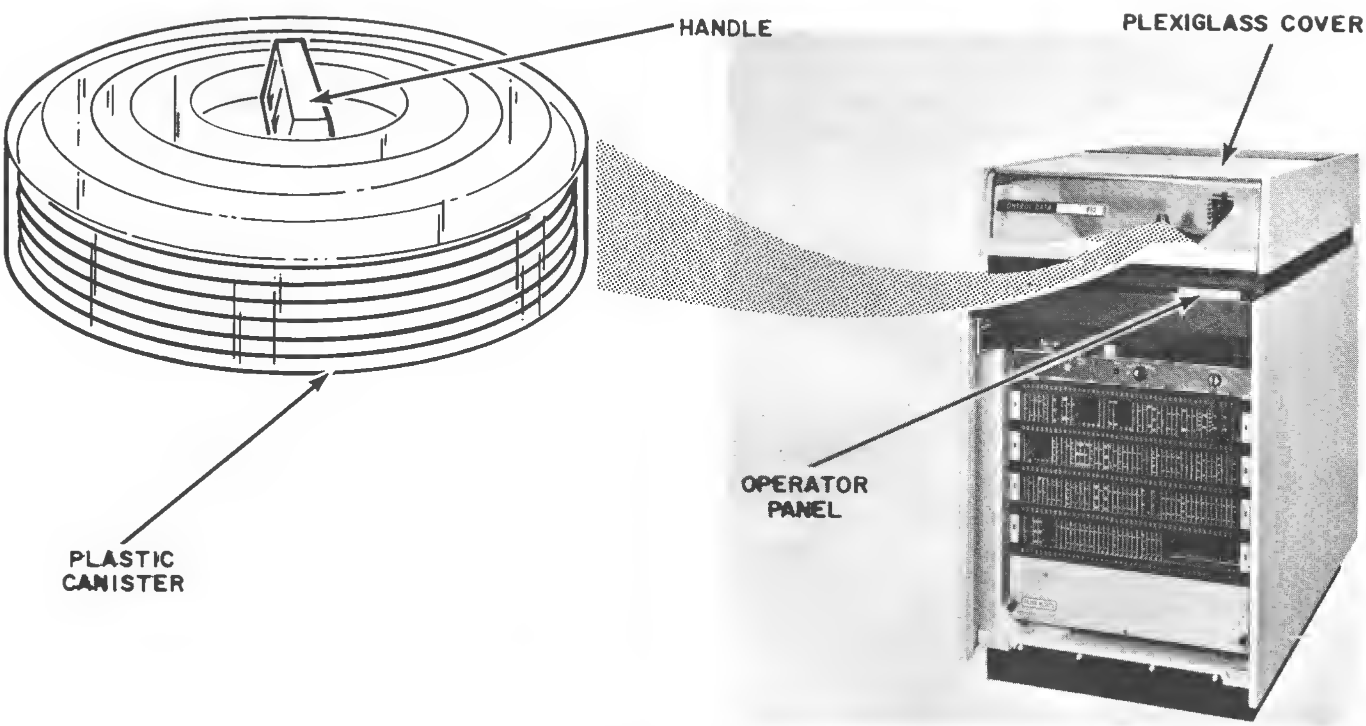


Figure 2-1-1 Disk Pack

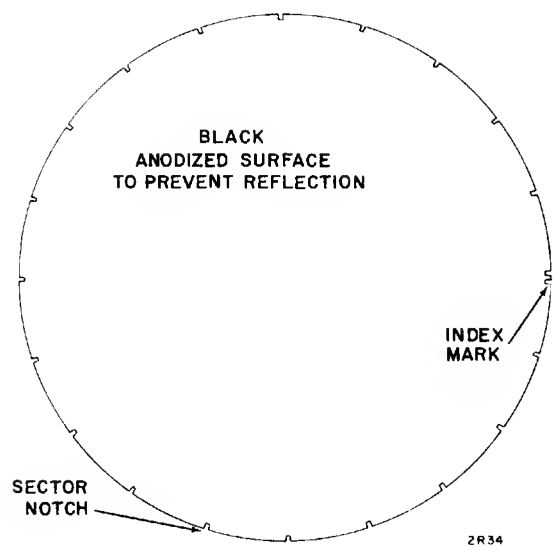
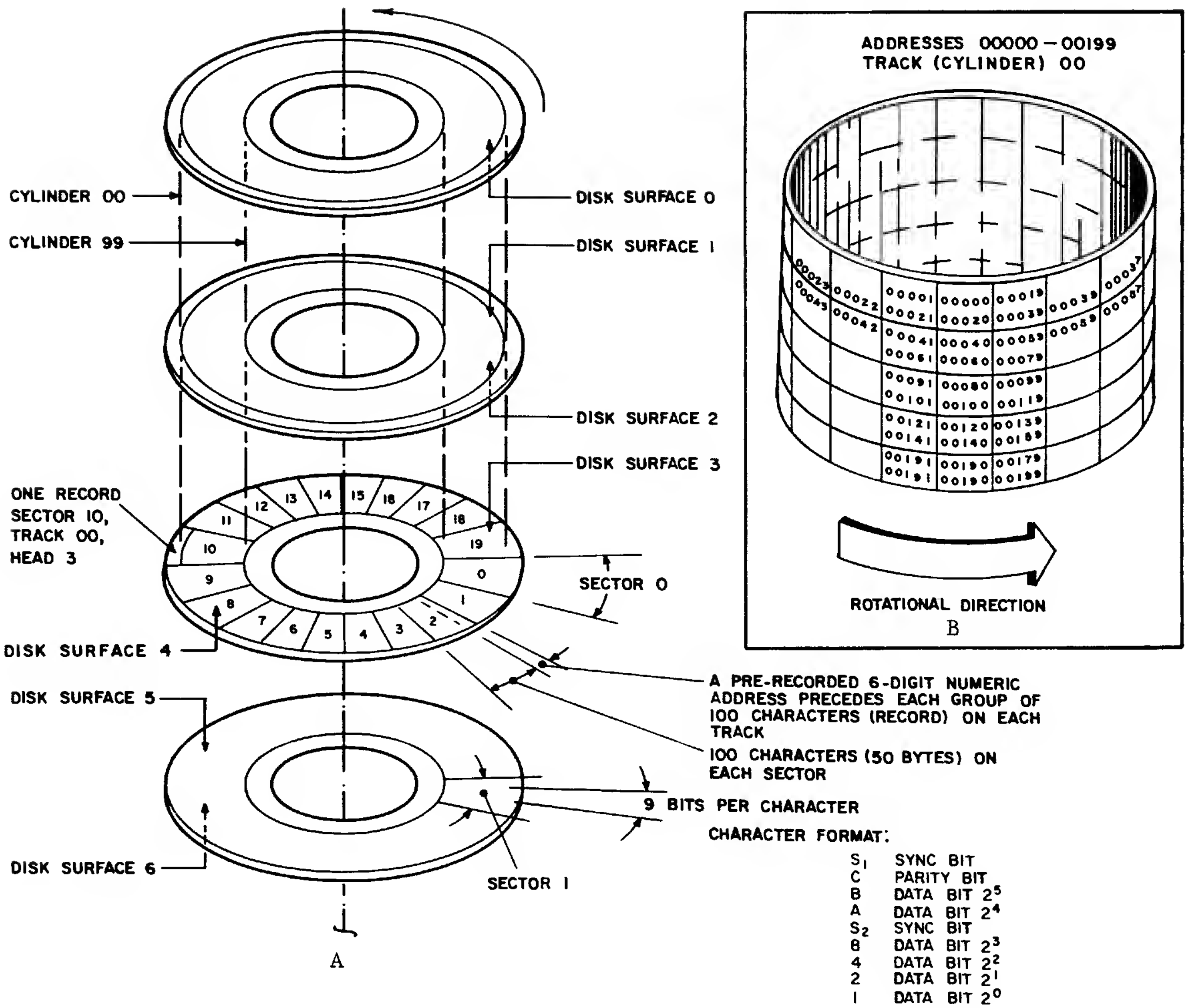


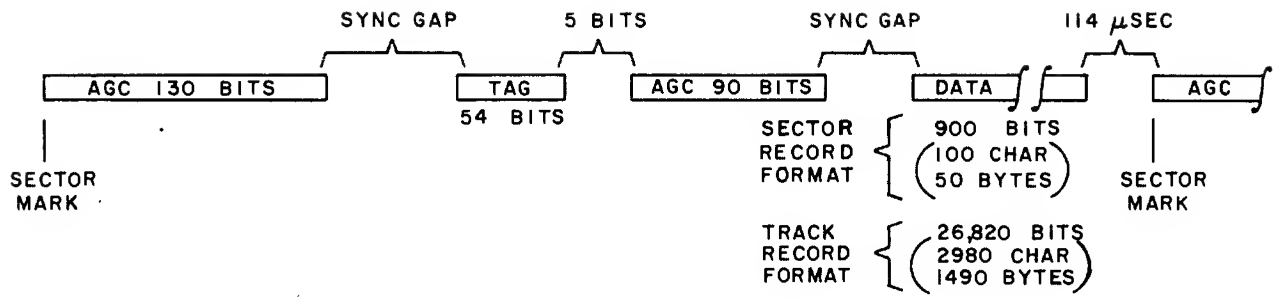
Figure 2-1-2 Sector Disk



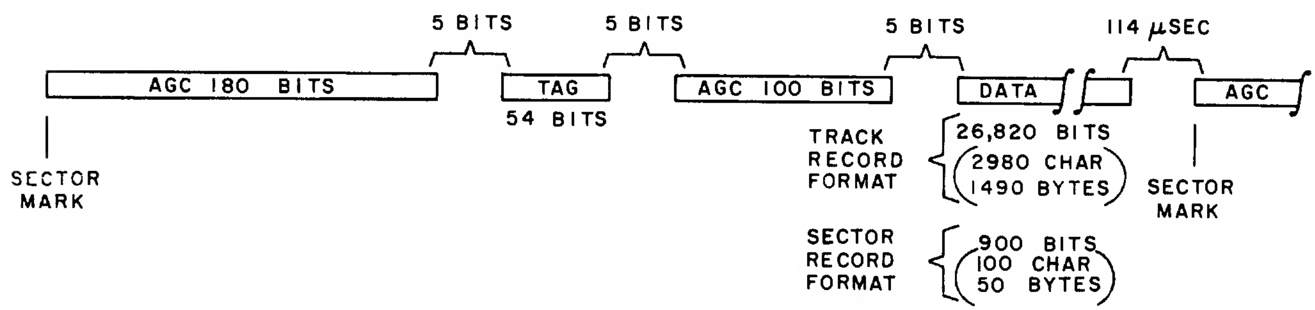
Sector, Track, and Cylinder Organization of a Disk Pack

TABLE 2-1-3. BCD/HOLLERITH/CODES

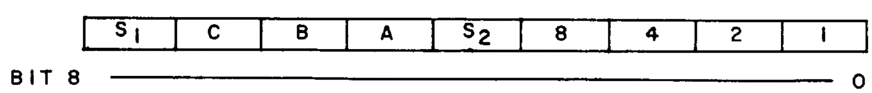
Internal BCD Code	Char	Card	Internal BCD Code	Char	Card
00	0	0	40	(minus) -	11
01	1	1	41	J	11, 1
02	2	2	42	K	11, 2
03	3	3	43	L	11, 3
04	4	4	44	M	11, 4
05	5	5	45	N	11, 5
06	6	6	46	O	11, 6
07	7	7	47	P	11, 7
10	8	8	50	Q	11, 8
11	9	9	51	R	11, 9
12		8, 2	52	-0	11, 0
13	=	8, 3	53	$	11, 8, 3
14	(dash) -	8, 4	54	*	11, 8, 4
15		8, 5	55		11, 8, 5
16		8, 6	56		11, 8, 6
17		8, 7	57		11, 8, 7
20	+	12	60	(Space)	Blank
21	A	12, 1	61	/	0, 1
22	B	12, 2	62	S	0, 2
23	C	12, 3	63	T	0, 3
24	D	12, 4	64	U	0, 4
25	E	12, 5	65	V	0, 5
26	F	12, 6	66	W	0, 6
27	G	12, 7	67	X	0, 7
30	H	12, 8	70	Y	0, 8
31	I	12, 9	71	Z	0, 9
32	+0	12, 0	72		0, 8, 2
33	.	12, 8, 3	73	,	0, 8, 3
34	)	12, 8, 4	74	(	0, 8, 4
35		12, 8, 5	75		0, 8, 5
36		12, 8, 6	76		0, 8, 6
37		12, 8, 7	77		0, 8, 7



A. READ FORMAT



B. WRITE FORMAT



C. CHARACTER FORMAT

Figure 2-1-4. Read and Write Track Formats

The first AGC block and the address block is termed "the header". The header and the data can be written independently at different times and by different machines. Therefore, it is necessary to have separate AGC blocks for the header and the data.

Track Record

Track record is a method of increasing the efficiency of storage by eliminating all but the first header on each track. The first header and data AGC remain in size to 26820 cells. The total number of characters which can be stored in one track mode is 2980. The total number of characters which can be stored in one track in sector mode is 2000 or 980 characters less than track mode. The addresses sequence in increments of 20 in track mode because the intermediate addresses are eliminated with the headers. Track records must always be separated from sector records by one track.

Character Format

The 852 is a BCD device, therefore the data is stored as BCD characters. The data is stored serially by using NRZI recording mode. This type of recording is not self-clocking. The 852 uses a 9 bit character (Figure 2-1-4C) of which two bits are used by the 852 to provide a form of self-clocking. These two bits are the S1 (sync one) bit and the S2 (sync two) bit. One bit of each character is used to establish even parity (C bit). The remaining 6 bits make up the standard BCD format (Table 2-1-3).

GENERAL OPERATION OF MAJOR COMPONENTS

SPINDLE DRIVE MECHANICS

Spindle and Brake Assembly

The spindle and brake assembly provides a locking point for mounting the disk pack, a drive pulley for turning the spindle at the proper speed, a brake for holding the spindle assembly in a fixed position when loading the pack, and a safety switch to assure that the disk pack is on and properly fastened to the spindle, prior to allowing any operational sequence.

Operation

The spindle (Figure 2-1-5) is the point at which the disk pack is attached to the disk drive. The male conical surface of the drive mates directly with the female surface of the disk pack.

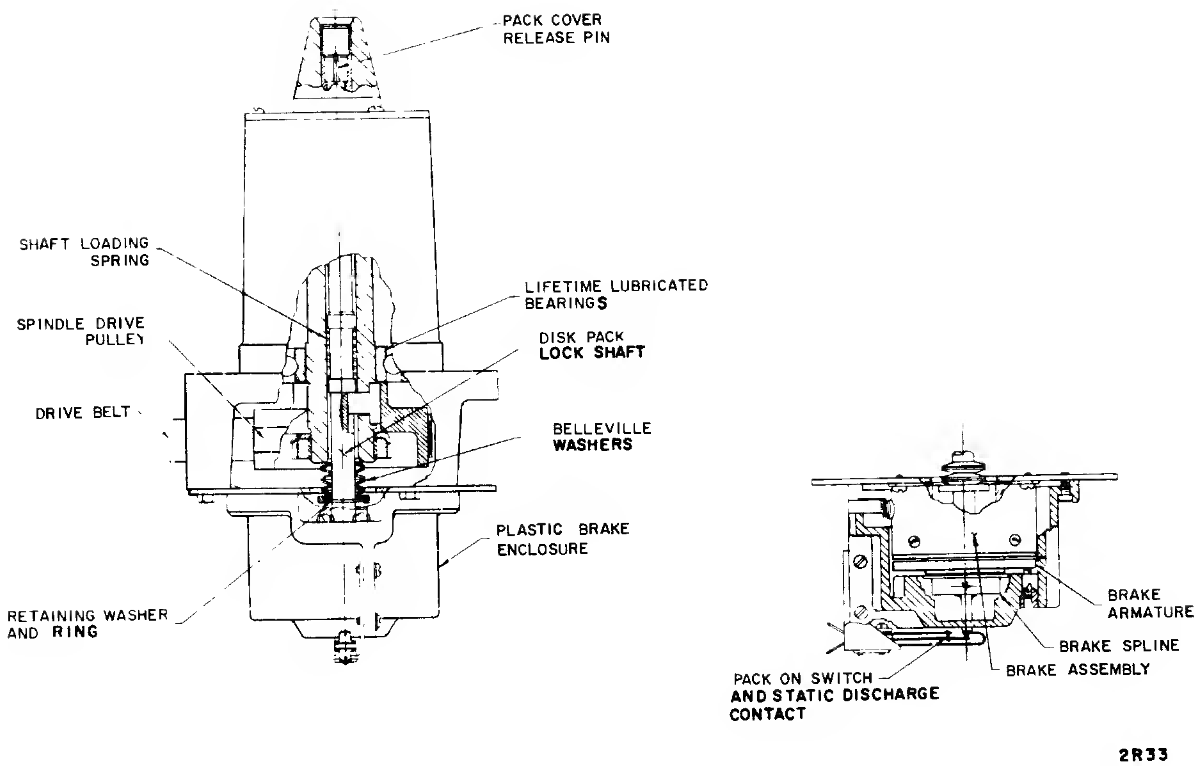


Figure 2-1-5. Spindle and Brake Assembly

Within the spindle is a free floating shaft containing internal threads that engage the male threads of a stud projecting from the disk pack. As the disk pack handle is rotated clockwise, the female threads on the spindle locking shaft are engaged, pulling upward on the spring mounted spindle shaft. This creates a verticle load which engages the two tapered sections. The nominal force between the two surfaces is about 200 pounds.

The spindle brake is engaged only when the disk drive is in a normal off condition, but with the primary power still available. This applies torque to the spindle for ease in disk pack replacement. The spindle brake slips at about 40 inch-pounds of torque.

As the lockshaft is pulled up during the disk pack replacement, the contacts of the pack-on switch are closed. This provides an indication of the pack-on status.

Physical Description

The spindle cone is made of stainless steel. Runout is held to less than .00015 inch (Figure 2-1-6).

Concentric with the spindle shaft is a pulley and brake assembly. The pulley is driven by a flat belt drive from the motor and provides a smooth transfer of power, minimizing velocity fluctuations. This assures a constant data rate which is necessary for disk drive compatability with other disk drives.

The spindle brake is attached to the lower end of the spindle shaft. The brake consists of two metal plates, one plate is fixed to the base plate and is stationary. The other plate is fixed to and rotates with the spindle shaft. An electromagnet draws the two plates together and prevents spindle shaft rotation when a disk pack is being installed.

A plastic housing covers the brake assembly and collects the particles which are worn from the brake.

Drive Motor

The spindle assembly is driven by a 1/3 HP, 208 VAC motor. The motor is mounted to the main casting. The drive motor brings the disk pack up to speed in about 4 seconds. Motor speed is 3600 RPM, which is reduced to 1500 RPM at the diskpack by the drive pulley ratio.

READ/WRITE HEADS

One head arm assembly is provided for each recording surface. The ten head/arm assemblies are mounted on the carriage assembly and oriented in two adjacent vertical lines (Figure 15).

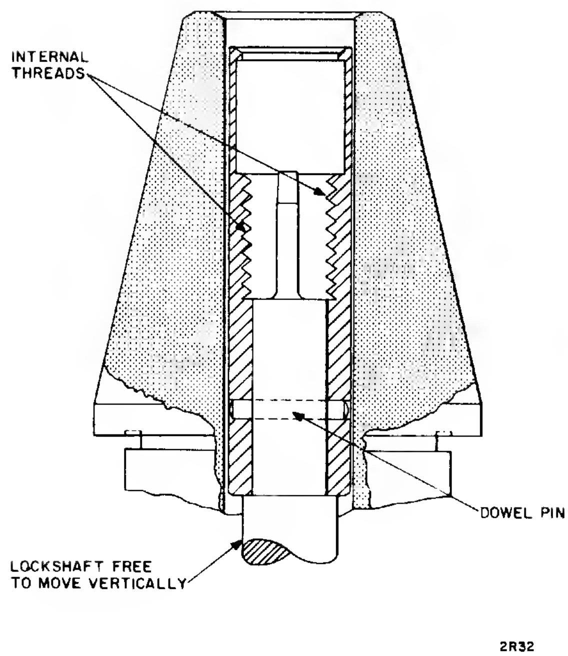


Figure 2-1-6. Spindle Cone

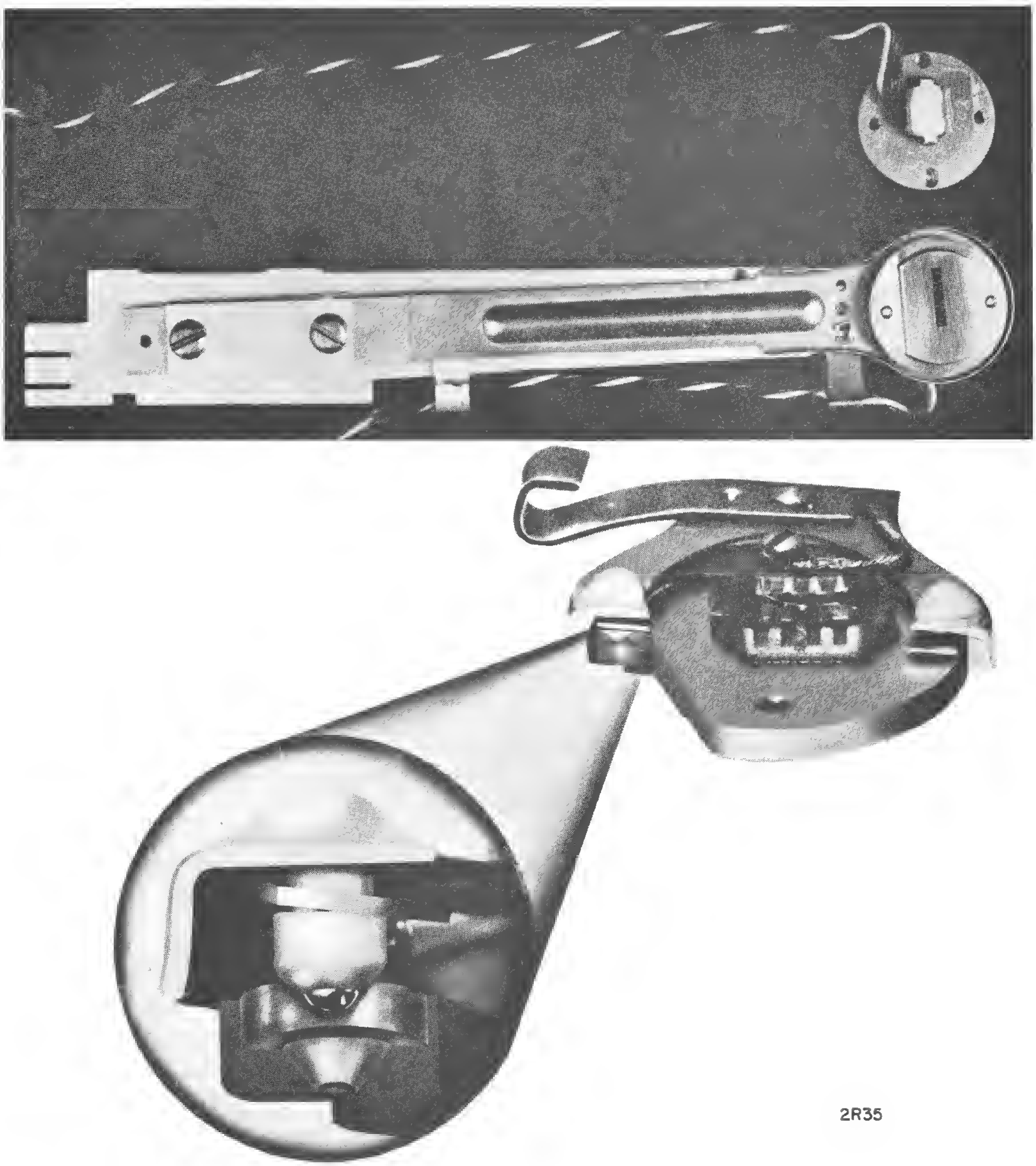


Figure 2-1-7. Head/Arm Assembly

The head/arm assembly (Figure 2-1-7) is made up of three major components: the head shoe, a gimbal ring and spring, and the support arm. Each head contains two gaps: a 0.018-inch wide erase gap, and a 0.010-inch wide read/write gap. The read/write and the erase ferrite gap inserts are mounted in a stainless steel shoe which is mounted to the support arm through a gimbal connector.

The gimbaling connector is a low-friction ball joint unit that requires no adjustment or maintenance. The ball joint is held to the arm by a circular spring, which allows the head to ride free on an air bearing over the disk.

The arm supports the head and prevents vibrations from affecting the flying height of the head over the disk surface. The head/arm assembly is mounted to the carriage through the head/arm guide plate and clamping strip (Figure 2-1-9).

Actuator Assembly

The actuator assembly provides the power and accuracy necessary to drive the heads out over the disk pack to the selected track within a minimum amount of time. Accuracy is necessary to maintain the random access specifications.

The actuator assembly consists of the carriage assembly, carriage drive motor, timing disk assembly, detent assembly, head loading mechanism, and the home cell assembly (Figure 2-1-8).

Carriage Assembly

The carriage assembly is made up of the main carriage casing, head arm assemblies, torsion arms, torsion arm loading gears, heads loaded latch assembly, and the carriage rack gear (Figure 2-1-9).

The main purpose of the carriage assembly is to accurately support the head arm assemblies, and to allow their movement to the requested position.

Total travel of the carriage is 3.3 inches, of which 1.3 inches is required to bring the heads from the retracted position to track 00. Motion is imparted to the carriage through the carriage rack gear, which is mounted to the carriage by four bolts.

The head/arm assemblies are mounted in slots in the main casting and held in position by a clamp. The head arm assemblies can be individually adjusted by loosening the clamp and moving the selected head/arm assembly along the slot in the main casting.

Loading of the heads is accomplished by the torsion arms and the torsion arm loading gears. The five torsion arm gears are vertically mounted in a row and are driven by the center gear. This circular movement, applied to the

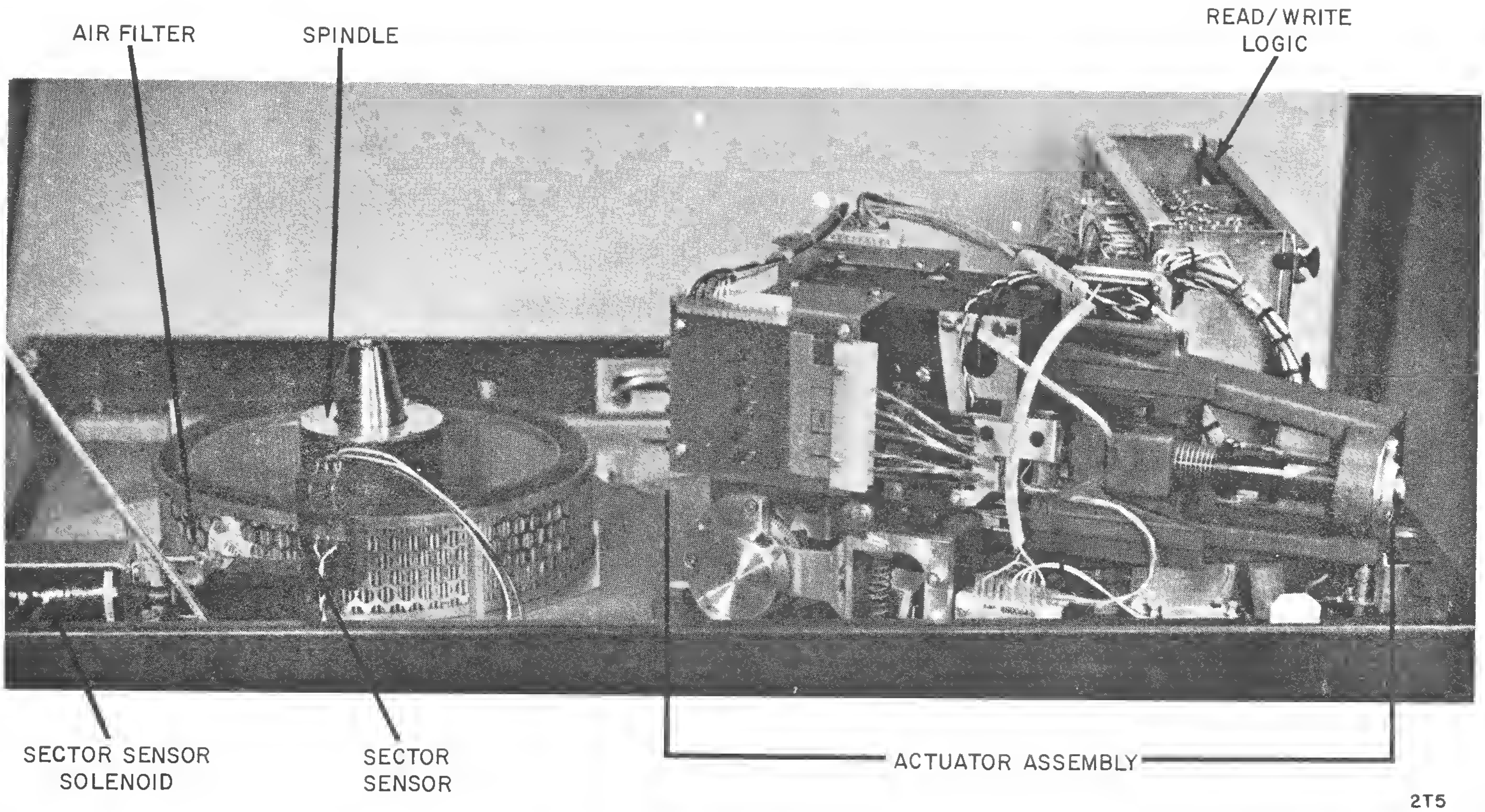


Figure 2-1-8. Actuator Assembly

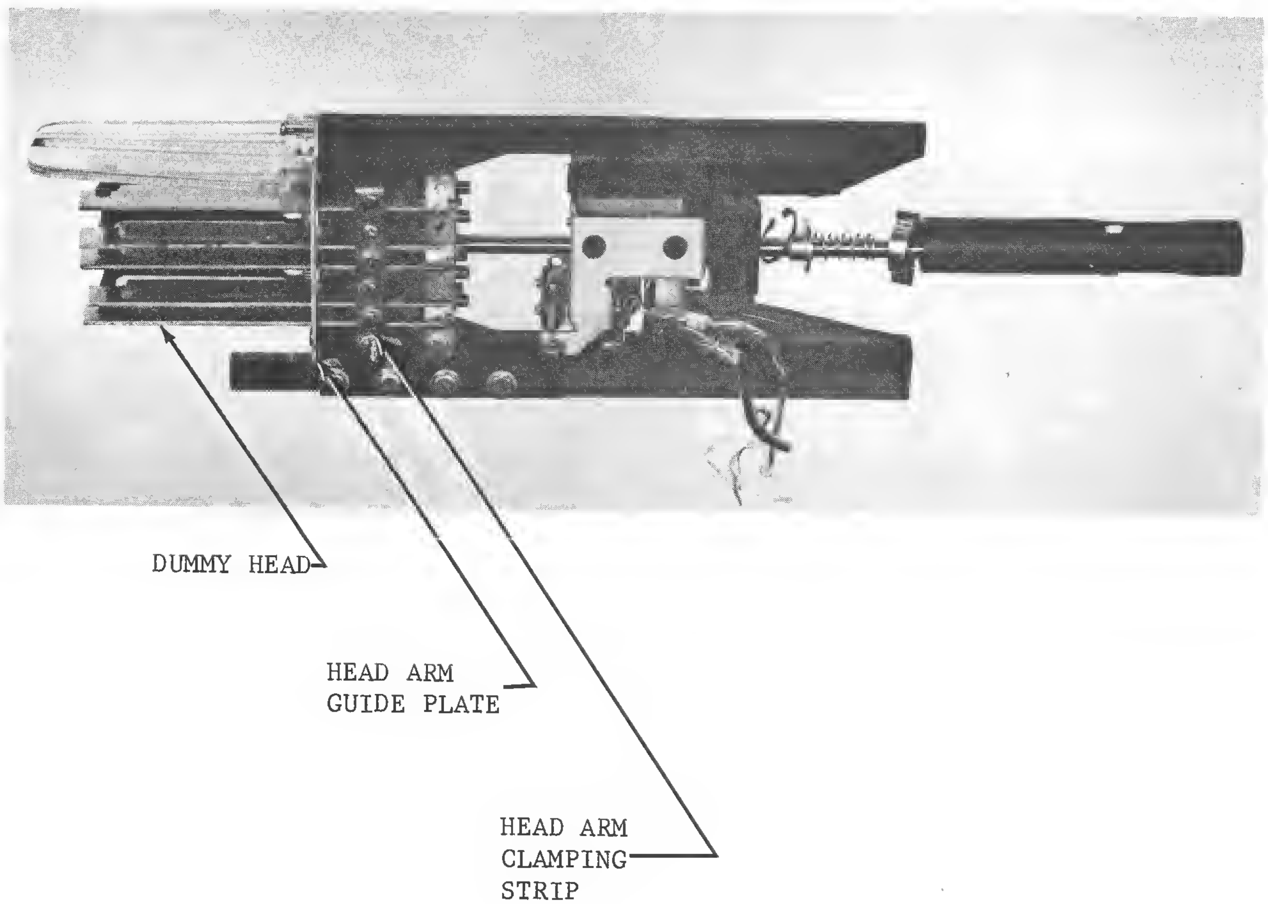


Figure 2-1-9. Carriage Assembly

torsion arms, is converted to a vertical force which is applied to the head/arm assemblies and drives the heads toward the disk surfaces. An equilibrium of forces is established when the heads are loaded so that the heads fly at a height of 120 micro-inches from the surface of their respective disks. A wedge of air between the disk and head creates a force away from the disk. This force is balanced by the force of the torsion arm.

The heads-loaded latch assembly holds the heads in the loaded position by locking the center gear shaft The latch is released in case of a power loss or normal power off sequence.

Carriage Drive Motor

The motor is an integral part of the carriage drive mechanism (Figure 2-1-10). The motor armature consists of a printed circuit rather than a conventional wire-wound iron core. This reduces the weight of the armature and allows higher rates of acceleration. The motor is coupled to the carriage through a flexible coupling to a pinion gear which drives the carriage rack gear.

The move command is applied to the motor in the form of current. This current drives the motor in either the forward or reverse direction. The amplitude and duration of the drive current determines the number of tracks that the carriage will move. When a maximum carriage movement of 99 tracks is required, full current is applied to the motor, accelerating the carriage at a maximum rate to a velocity of about 35 inches per second.

The polarity of the applied direct current determines the direction of the motor rotation.

Timing Disk

The glass timing disk is connected to the motor shaft and as the motor rotates, a corresponding rotational movement is imparted to the timing disk (Figure 12). A pair of photo cells sense each slot on the timing disk as it passes.

The glass disk is photo-etched with three concentric rings of transparent slots (Figure 2-1-12). The outer ring contains 1020 slots, the middle ring contains 203 slots, and the inner ring contains 100 slots. The middle ring is not used by the 852 disk drive. The inner ring (100 slots) is used to determine the track positions on the disk pack. Each slot corresponds to a track position. As each track is crossed, a slot in the timing disk allows light from the exciter lamp to reach a phototransistor producing an output pulse. This pulse is used to step a counter which indicates the track position of the read/write heads.

The outside track (1020 slots) provides about ten times as many pulses. These pulses are used for speed control of the motor. The pulses are supplied to the logic, where the time between pulses is measured to indicate the speed of the carriage. If the carriage speed is too great, current is applied

to the motor in the reverse direction, dynamically braking the carriage to the proper speed. When the time between pulses is proper, the motor current is again applied in the forward direction.

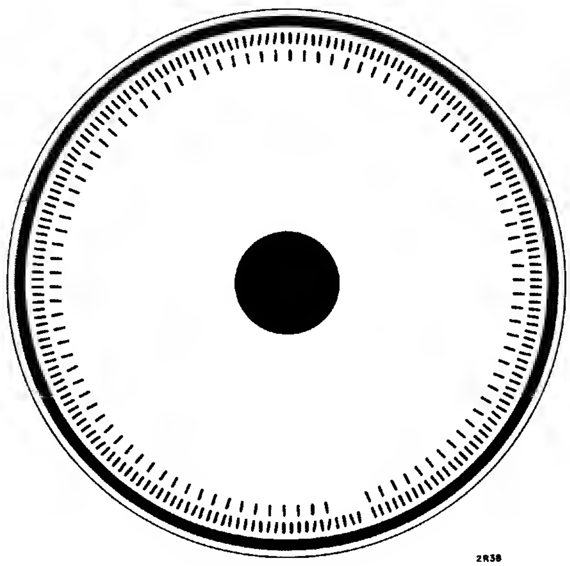


Figure 2-1-12. Timing Disk

Detent Assembly

The detent assembly holds the carriage in a fixed position, with the heads at the desired track, when no current is applied to the carriage drive motor.

The detent assembly consists of a detent gear, a spring-loaded detent pawl, and a detent solenoid (Figure 2-1-13).

The detent gear contains 102 notches, one notch for each track plus one extra at each extremity, and -1 and track 100. The detent gear is rigidly connected to and rotates with the pinion shaft. The detent solenoid draws the detent pawl from the detent gear and allows the pinion shaft to rotate as the carriage is being moved to a new position. When the desired track is reached, reverse current is applied to the drive motor which dynamically brakes

the carriage to a stop. At this time the detent solenoid is de-energized and the spring-loaded pawl drops into the detent gear, locking the pinion gear and carriage into position.

The detent pawl is mounted on a spring-loaded yoke which will absorb the shock produced if the pawl attempted to engage the detent gear before it was fully stopped. The spring-loaded yoke also allows the detent to rachet in the reverse direction. This allows the operator to manually push the carriage assembly to the retract position in the event of some failure which would not retract the carriage automatically.

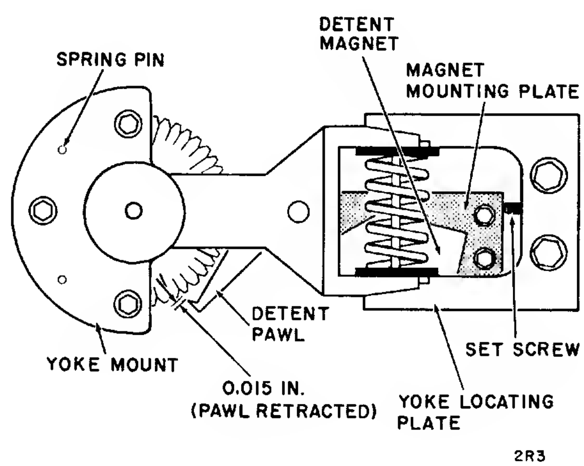


Figure 2-1-13. Detent Assembly

Head Loading Mechanism

The head loading mechanism applies sufficient pressure to the read/write heads to hold them to within 120 micro-inches of the disk surface.

The head loading mechanism consists of the head loading cam, cam latch solenoid, cam release lug washer and spring, cam follower, center torsion and cam follower rod, the heads-loaded latch solenoid and switch, torsion arm gears, and the torsion spring.

When power is off, the heads are retracted and unloaded to facilitate installation of a disk pack. When power is turned on and the disk pack is up to speed, the heads are moved forward into the area between the disk surfaces and loading pressure is applied.

When power is sequenced up, the head-loading cam is moved into a locked position by the cam latch solenoid. As the carriage moves forward, the cam follower rides the cam surfaces and rotates the center torsion and cam follower rod 60 degrees. This rotation is imparted through the middle torsion arm gear to the four remaining torsion gears.

A torsion arm, mounted to each gear, is connected between a pair of heads (Figure 2-1-14). By rotating the arm, one head is forced downward toward one disk surface and the other head is forced upward toward another disk surface. The five arms, each loading two heads, will load all ten heads.

At the end of the 60-degree rotation, the heads are loaded and the heads-loaded latch engages the center torsion and cam follower rod, locking it in place. The heads-loaded latch also transfers the heads-loaded switch, which releases the cam latch solenoid.

The heads will remain loaded until power is lost or turned off. When power is turned off the heads-loaded latch will release the center torsion and cam follower rod, allowing the heads to slowly unload under control of the air damper.

Home Cell Assembly

The home cell assembly indicates when the carriage is in the extreme positions at which the heads will fly (track -1 and track 100).

The home cell assembly consists of the phototransistor excitor lamp assembly, and the home cell mask (Figure 2-1-10).

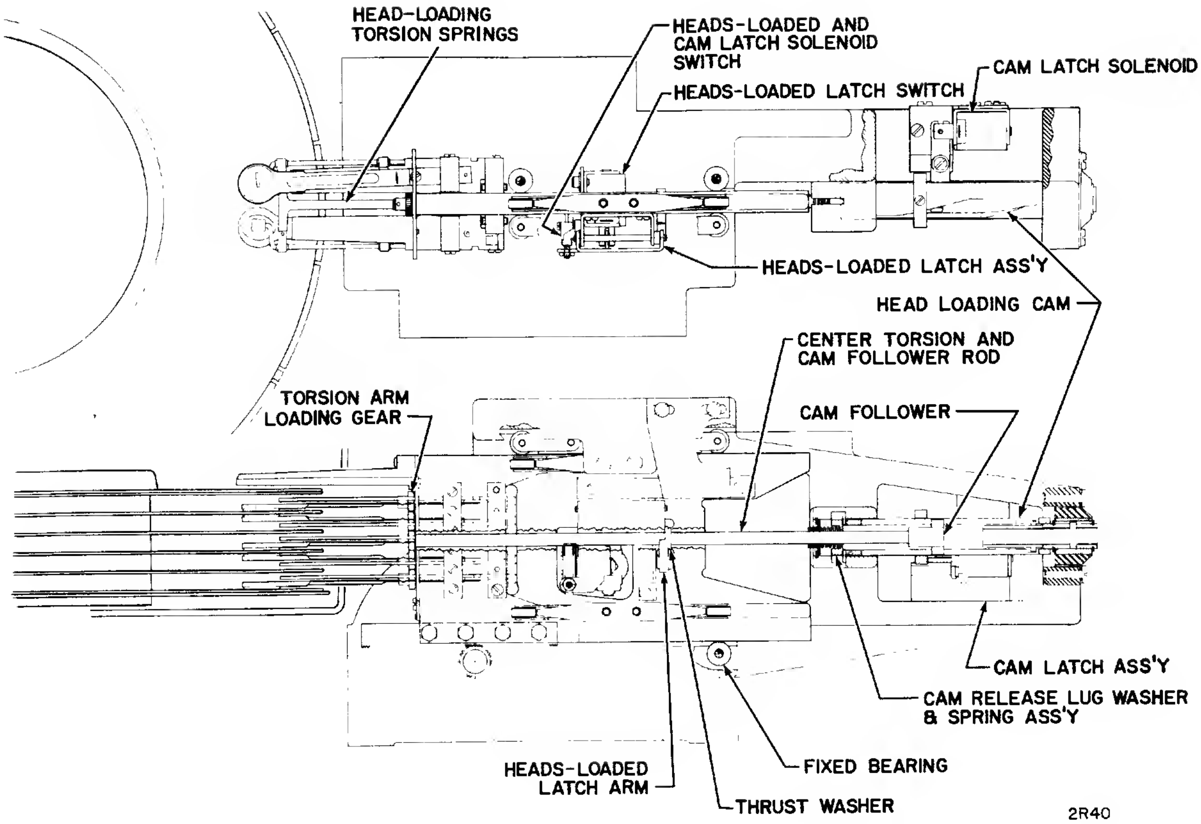
The home cell mask is connected to and moves with the carriage assembly. The mask contains two slots which allow light to pass from the exciter to the phototransistor when the carriage is at position -1 or position 100. The pulse generated by the phototransistor is used to indicate to the logic that the carriage has gone beyond the recording area of the disks.

Sector Sensor Mechanism

The sector sensor detects the notches which are cut in the bottom disk of the disk pack to indicate the sector and index positions.

The sector sensor mechanism consists of two exciter lamps, two phototransistors, and the sector sensor solenoid (Figure 2-1-15).

The sector sensor is pivot-mounted on the main casting. When the disk pack is in place and the disk drive is turned on, the solenoid is energized. This pivots the sector sensor so that the exciters and phototransistors overlap the



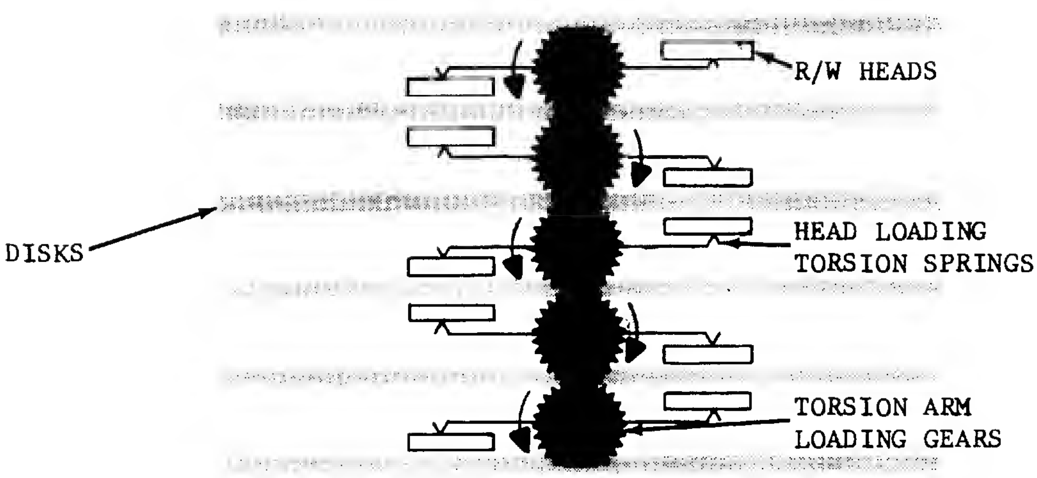


Figure 2-1-14. Head Loading Mechanism

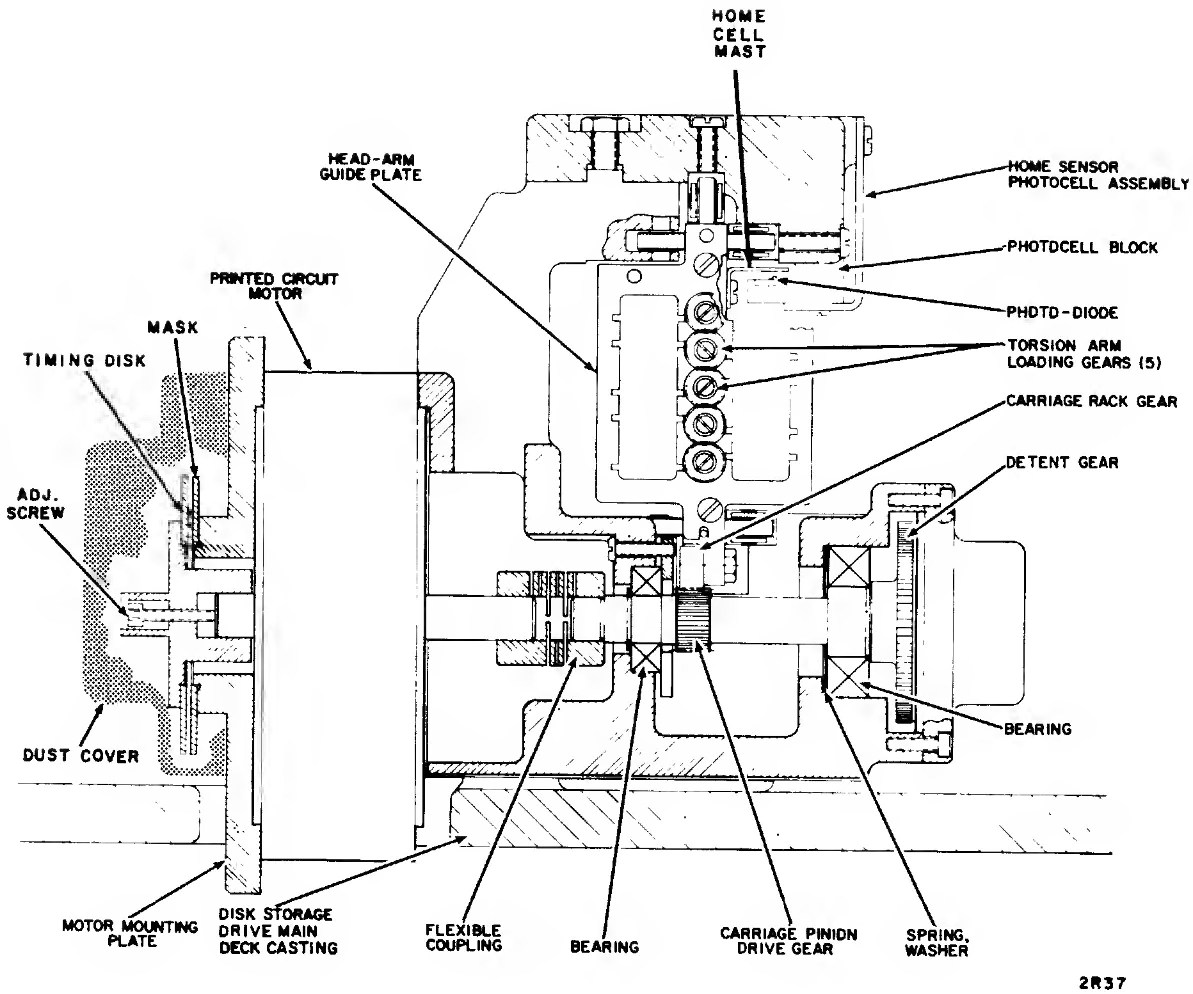


Figure 2-1-10. Front View Actuator Cutaway

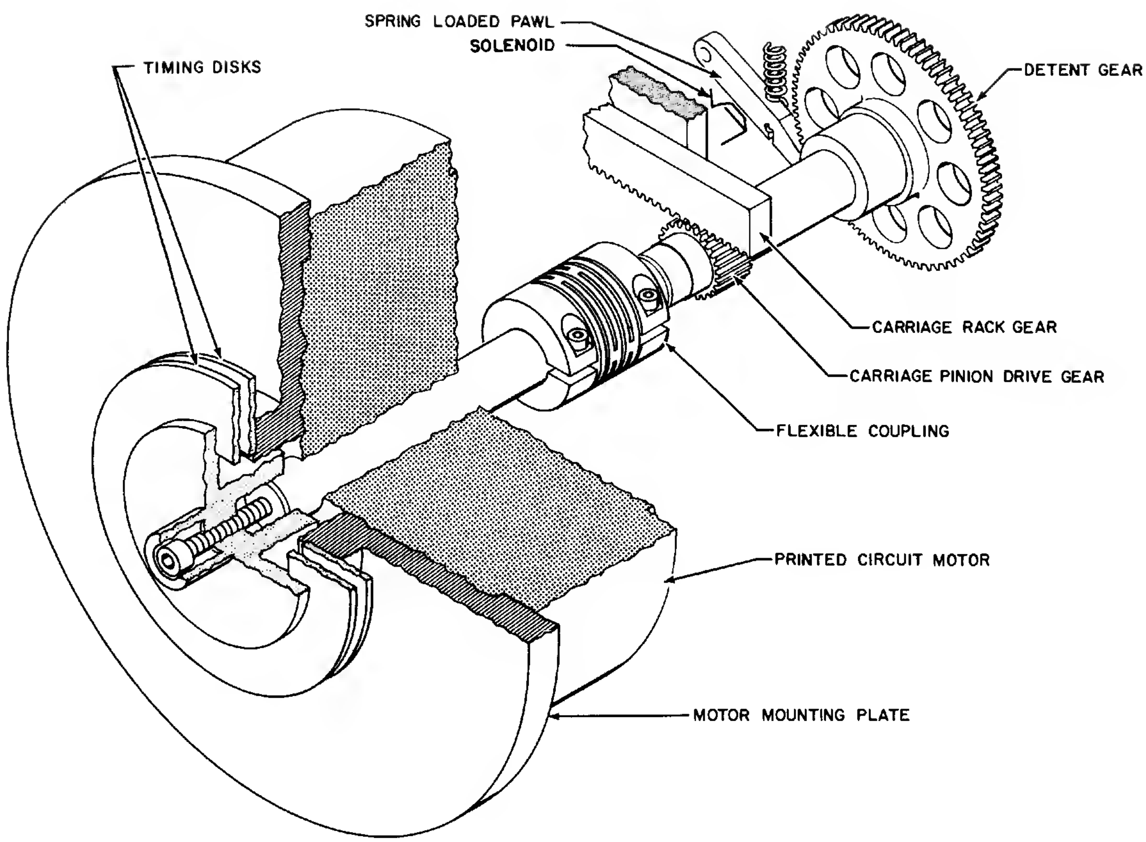


Figure 2-1-11. Carriage Drive and Positioning Mechanism

bottom disk of the disk pack. When the solenoid is de-energized, a spring retracts the assembly from the edge of the bottom disk to allow removal or replacement of the disk pack.

The notched sector disk, overlapped by the sector sensor, blocks the light from the phototransistors so that output pulses are provided only when a notch passes between the phototransistors and the exciter lamps.

Two notches are provided as an index mark or reference point for counting sectors. The two phototransistors are separated by the same amount as the two reference notches. The coincidence of the two pulses is detected as index. An additional 19 notches divide the disk pack into 20 sectors. Each notch is sensed twice, first by the pre-sector cell and secondly by the sector cell.

LOGIC CHASSIS

Operator Panel

The operator panel is located on a ledge above the logic chassis for ease of operation and observation (Figure 2-1-16).

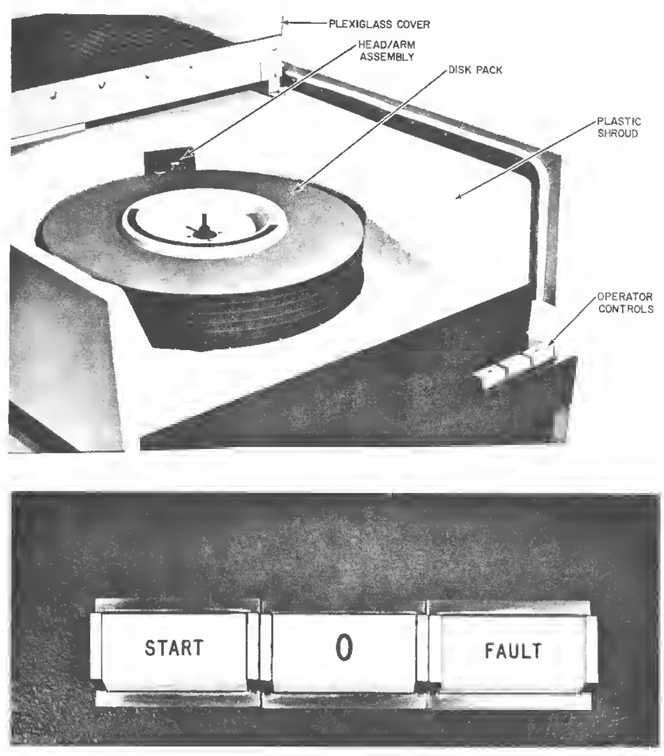


Figure 2-1-16. Operator Panel

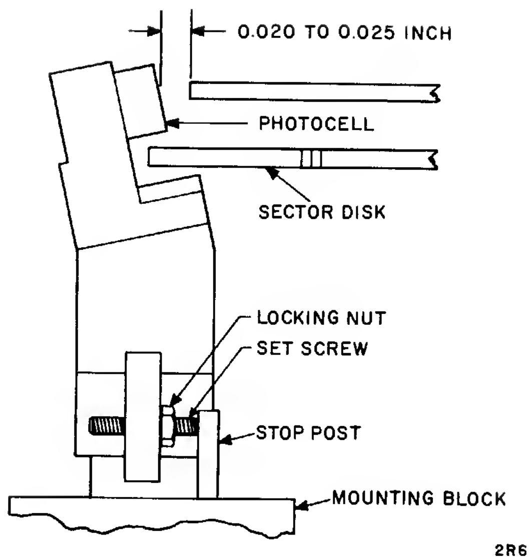


Figure 2-1-15. Sector Sensor

TABLE 2-1-4. CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
Operator Panel	
START switch/indicator	The START switch/indicator (when depressed to light) engerizes the spindle drive to begin a first seek sequence if the disk pack is in place, the plexiglass cover is closed, and the sequence relay is energized by the control unit.
Unit Number indicator	The unit number is the number assigned to the disk storage drive unit when several units are used in the same system. The unit Number indicator lights when the disk drive heads are loaded.
FAULT switch/indicator	The FAULT switch/indicator lights when the following fault conditions exist: 1. More than one head is selected. 2. Select read and write exist at the same time. 3. Select read and erase exist at the same time. 4. Erase is selected with no write driver. 5. Erase is selected in combination with both write drivers. 6. One or both write drivers are on with no erase driver. 7. More than one unit is selected. The fault flip-flop in the logic section is cleared by depressing the FAULT switch/indicator. The fault flip-flop will remain cleared until the original source of the problem reappears.

Main Logic Chassis

The disk drive logic is conta ned on a forced air cooled chassis (Figure 2-1-17). The chassis is mounted in the lower front of the machine and is hinge-mounted to provide easy access to the wiring. Two blowers, located in the closed section at the bottom of the chassis, direct cooling air . A filter is located in the air intake side of the blowers.

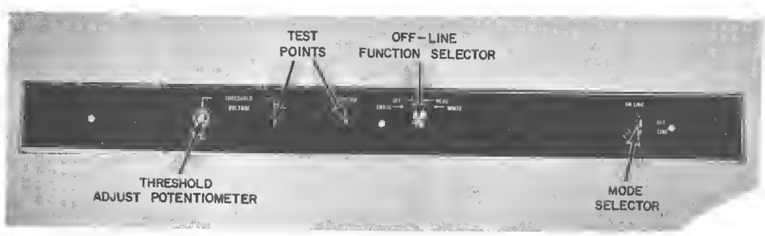
A connector panel is attached to the rear of the chassis. All intra-cabling connections are made at this panel.

Read/Write Chassis

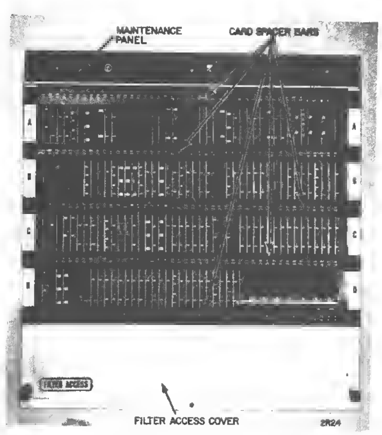
The read/write chassis is mounted on the main casting, adjacent to the actuator. This allows short leads to the read/write heads and provides a better signal-to-noise ratio.

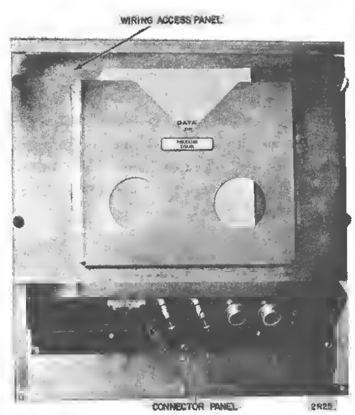
Maintenance Panel

The maintenance panel is mounted to the logic chassis above the top row of logic boards. This locates the panel in a position which is available only to maintenance personnel (Figure 2-1-17).



Logic Chassis Maintenance Panel





Rear View

Figure 2-1-17. Logic Chassis

TABLE 2-1-5. CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
Logic Chassis Maintenance Panel	
OFF LINE/ON LINE switch	The OFF LINE/ON LINE key switch transfers the control of the disk storage drive unit from the controllers to the unit itself, and vice versa. When the key switch is in the OFF LINE position, the off line function selector switch is activated and the various functions (ERASE, READ, WRITE, and OFF) can be performed as selected.
THRESHOLD LEVEL	The THRESHOLD LEVEL potentiometer controls the threshold level of the peak detector. The voltage level can be monitored at the test point adjacent to the potentiometer.
Actuator Assembly	
Track number dial	The track number dial is a part of the detent gear and indicates the track number at which the carriage is detented. The dial is read at the pointer (located above pawl).

POWER SUPPLY

The disk drive has a self-contained power supply that is mounted behind the rear panel (Figure 2-1-13). The AC/DC power developed by the power supply is applied to the logic chassis, to the actuator, and to the spindle drive system. Power control is accomplished from the power supply control panel (Figure 2-1-19).

The power supply is mounted on slide rollers to allow extension of the supply from the chassis. The front panel of the supply may be lowered to allow access to the wiring and components.

The unit is cooled by forced air from two heavy-duty fans.

TABLE 2-1-6. CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
Power Supply Control Panel	
MAIN POWER circuit breaker	The MAIN POWER circuit breaker controls the a-c voltage to the disk storage drive unit.
CONVENIENCE OUTLET circuit breaker	The CONVENIENCE OUTLET circuit breaker controls the a-c voltage to the convenience outlet.
$\pm$ 20 volts dc circuit breakers	The $\pm$ 20 volts dc circuit breakers control the application of the $\pm$ 20 volt dc potentials to the logic section.
+40 volts dc circuit breaker	The +40 volts dc circuit breaker controls the application of +40 volt dc potential to the write supply. NOTE: An indicator is provided with each of the above circuit breakers. Each indicator is illuminated when the corresponding voltage is present. Test points are also provided as service aids to test the various voltage levels.
DETENT circuit breaker	The DETENT circuit breaker controls the +20 volt dc to the detent magnet.
ACCESS MOTOR circuit breaker	The ACCESS MOTOR circuit breaker controls the +20 volt dc potential to the access motor.
Elapsed time meter	The elapsed time meter indicates the spindle drive motor operating time (pack rotating).

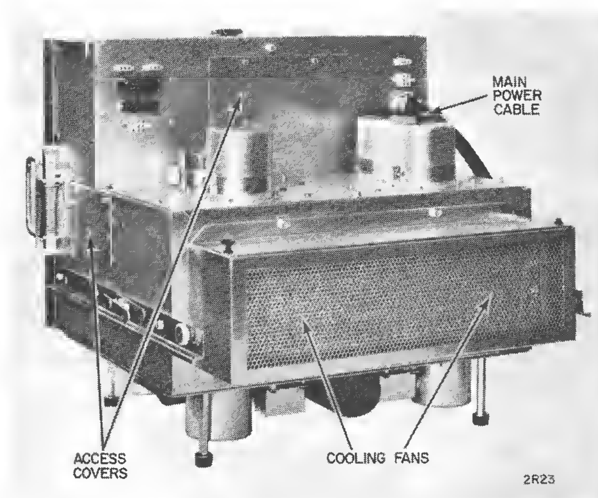


Figure 2-1-18. Power Supply

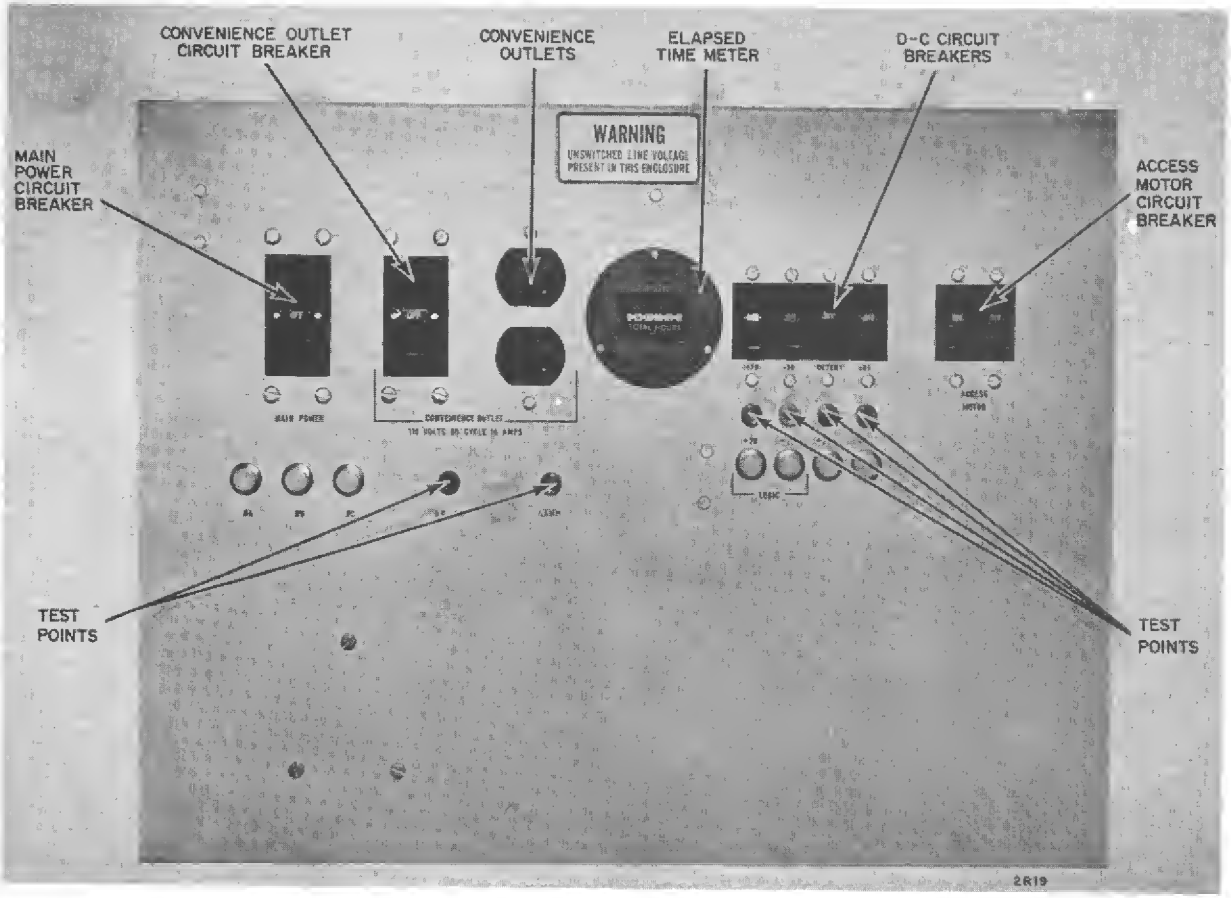


Figure 2-1-19. Power Supply Control Panel

CHAPTER II

DETAILS OF OPERATION

CHAPTER II

DETAILS OF OPERATION

GENERAL DESCRIPTION

The disk storage drive is a peripheral storage device that performs three basic functional operations: automatic cycling up of power (once the unit is sequenced); positioning the head/arm assemblies over the selected track; and performing the read/write/erase operation.

UNIT SELECT AND TRACK POSITIONING

To activate the disk drive, a unit sequence level (Figure 2-2-1)is applied to the power supply. With a unit sequence input applied, the disk storage drive unit automatically cycles the power up and performs a first seek to being the unit to a ready condition.

During first seek the heads are loaded and the carriage is positioned such that the heads are located at track 00. Once the power-up sequence has been completed and if the unit is selected, the select on-line and the on cylinder signals are supplied to the controller. The selected disk storage drive is now ready to receive the destination and seek commands.

The destination command starts with a begin operation reset pulse that clears the seek overlap decrement counter. The 8-unit seek length is then gates into the decrement counter by the seek length transfer pulse.

A direct seek input command initiates the movement of the carriage, and drives the heads directly to the selected track. Assuming the number of tracks to go is greater than 35, the carriage is accelerated toward maximum velocity. As the carriage is moved to reposition the heads, the track photocell provides a pulse, between each track, to the access control logic. The speed photocell also provides pulses that indicate the speed of the carriage as the heads are moved to the selected track. When the track information indicates that there are fewer than 35 tracks to go, the carriage is dynamically braked to a speed of 17 ips. Forward drive continues at 17 ips until the number of tracks remaining is reduced to fewer than 10. The carriage is then dynamically braked to 6 ips. Forward motion of the carriage continues under power at 6 ips until fewer than 4 tracks remain at which time the carriage is dynamically braked to a speed of 2 ips. This speed is sustained until the selected track is reached. Once the track is reached, a spring-loaded pawl engages the carriage detent gear, positioning the heads very accurately over the selected track.

When all carriage motion has stopped, an on-cylinder signal is supplied to the controller as an indication that the heads are in position and ready for a read/write operation.

A return-to-home seek is used to establish a definite reference point, since position of the carriage may be unknown at that time. Using return-to-home seek, the carriage is driven first to the carriage home position, regardless of the initial position of the carriage, and then performs a direct seek to the selected track.

READ/WRITE/ERASE OPERATION

When the write gate is applied to the read/write circuits, the write drive circuit is enabled. The appropriate disk drive head is then selected in accordance with the disk surface desired for recording. This is accomplished through one of the ten head select lines. Following selection of the head, the location of the required sector must be determined. As each sector is reached, the 54-bit address is read and compared with the selected sector address in the controller. When comparison indicates that the sector being read is the selected sector, the write data input lines are enabled by the controller. The record is then written on the selected sector. Erase current is applied to the erase head during the write operation to ensure a clear writing surface.

A read operation is performed in a manner similar to the write operation, except that once the selected sector is located, the read data lines are again enabled by the controller.

TABLE 2-2-1. INPUT/OUTPUT LINES

SIGNAL	FUNCTION
Position Control	
Input Lines	
Unit select (0 through 4)	Determines which disk storage drive is selected.
Home seek/Direct seek	Initiates the positioning operation
Reverse	Moves the carriage toward track 00 in a direct seek operation.
Begin operation reset	Clears the decrement counter in the seek overlap section of the disk storage drive.
Seek length transfer	Gages the new seek length to the decrement counter.
Seek length (8 lines)	Carry the seek length to decrement counter.

TABLE 2-2-1. INPUT/OUTPUT LINES (Cont'd)

Output Lines	
Seek on line	Indicates that the unit select is available (motor on and heads loaded).
On cylinder	Indicates that the positioning mechanism has stopped and is detented.
Data and Data Control	
Input lines	
Head select (0 through 9)	Selects the head to be enabled.
Write gate	Enables the write/erase drive circuits in the disk storage drive.
Clock gate	Enables the main timing oscillator in the disk storage drive.
Signal gate	Enables the analog read circuits during a read operation.
Read gate	Enables the output of digital data to be read from the disk storage drive.
AGC disable	Disable the automatic gain control of the disk storage drive at the beginning of read operations to exclude switching noise from the circuits.
Write data	Carries information to be written from the controller to the disk storage drive.
Output lines	
Sector/Presector	Indicate the starting point for a sector or for the index mark.
Data unsafe	Indicates a malfunction in the disk storage drive read/write circuits.
Clock (Ø A)	Main timing output signal supplied to the controller for data synchronization.
Read data	Carries digital information read from data to the controller.

POWER SUPPLY

INTRODUCTION

The disk storage drive power supply requires a three-phase, four-wire, 208vac, 50/60 cycle input. The power supply provides an adjustable ±20vdc, a fixed +22vdc, and a fixed +40vdc as output voltages. The power supply is manufactured by Control Data Corporation. The following sections provide information for proper operation and maintenance of the power supply.

SPECIFICATIONS

The following specifications apply to the disk storage drive power supply.

Physical

Length	22-½ inches
Width	21-5/8 inches
Height	18-3/4 inches
Weight	135 pounds

Electrical

Input voltage	208 volts, 50/60 cycle, three-phase at 3 amps per phase.
Output voltage	+20 volts ±5% (adjustable) at 2 amps maximum
	+20Y volts +20%, -10% at 6 amps maximum average
	+20X volts +20%, -10% at 6 amps maximum average
	+24 volts ± 15% at 100 milliamps
	+40 volts ± 10% at 0.5 amp maximum
Overload Protection	Main power: 5-amp CB Convenient outlet: 10-amp CB +20v dc: 2-amp CB -20 v dc: 6-amp CB Detent: 5-amp CB +40 v dc: 1/2-amp CB Access motor: 5-amp CB

THEORY OF OPERATION

General Description

The disk storage drive unit power supply is completely solid state to provide low dissipation and high reliability to the operating system. The power supply provides an adjustable ± 20 volts dc to the logic chassis, +22 volts dc to the access motor and detent solenoid, and +40 volts dc to the write drivers.

These voltages are sequenced and coupled to the related circuit in such a way as to prevent improper head loading, track accessing, or disk movement.

The three-phase, four-wire, 208 volts input power is applied through the closed contacts of the Main Power circuit breaker to the primary windings of transformer T01, to the line voltage indicators, and to the fan motors.

The line voltage indicators, DS04, DS05, and DS06, are connected between the three-phase input wires and the neutral wire, to provide an indication of the power applied.

Phase A of the primary power, is applied to the two blower motors in the logic chassis and to the two fan motors in the power supply.

Power (phase B and phase C) applied to the primary of transformer T01, is coupled to the secondary. Transformer T01 is a ferroresonant transformer (with parallel capacitances) that is maintained in resonance by the applied voltage. Consequently, the transformer secondary voltage tends to remain constant, regardless of the voltage variation of the applied signal or the load applied signal or the load applied to the secondary. The voltage developed across the secondary of T01 is coupled from pins 7 and 5 to the primary of transformer T02, and from pins 8 and 9 to full-wave bridge rectifier diodes CR01 and CR02.

The a-c voltage applied to T02 is transformer coupled to the center-tapped secondary. As pin 3 of the secondary goes positive, pin 5 is driven negative, and electron flow through the half-wave rectifier circuit is from pin 4 to T02, through capacitor C07, and through diode CR03A to pin 3 of T02. This charge capacitor C07, driving the junction of C07 and CR03A position with respect to ground. As pin 5 goes positive, electron flow through the circuit is from pin 4 to T02, through capacitor C07, and through diode CR03B to pin 5 of T02. This charges capacitor C07 toward +40 volts dc. Indicator lamp DS07 provides an indication that +40 volts dc is available to the write circuit.

The ac voltage applied to the full-wave bridge circuit is developed in the following manner. As pin 8 goes positive, pin 9 is driven negative and electron flow is from pin 9, through rectifier diode CR02A, through capacitor C01, to charge the capacitor towards -20 vdc. With pin 8 positive, electron flow is from pin 9 of T01, through capacitor C03, then through rectifier diode CR01B to pin 8 of the transformer. Capacitor C03 is charged toward +20 volts dc.

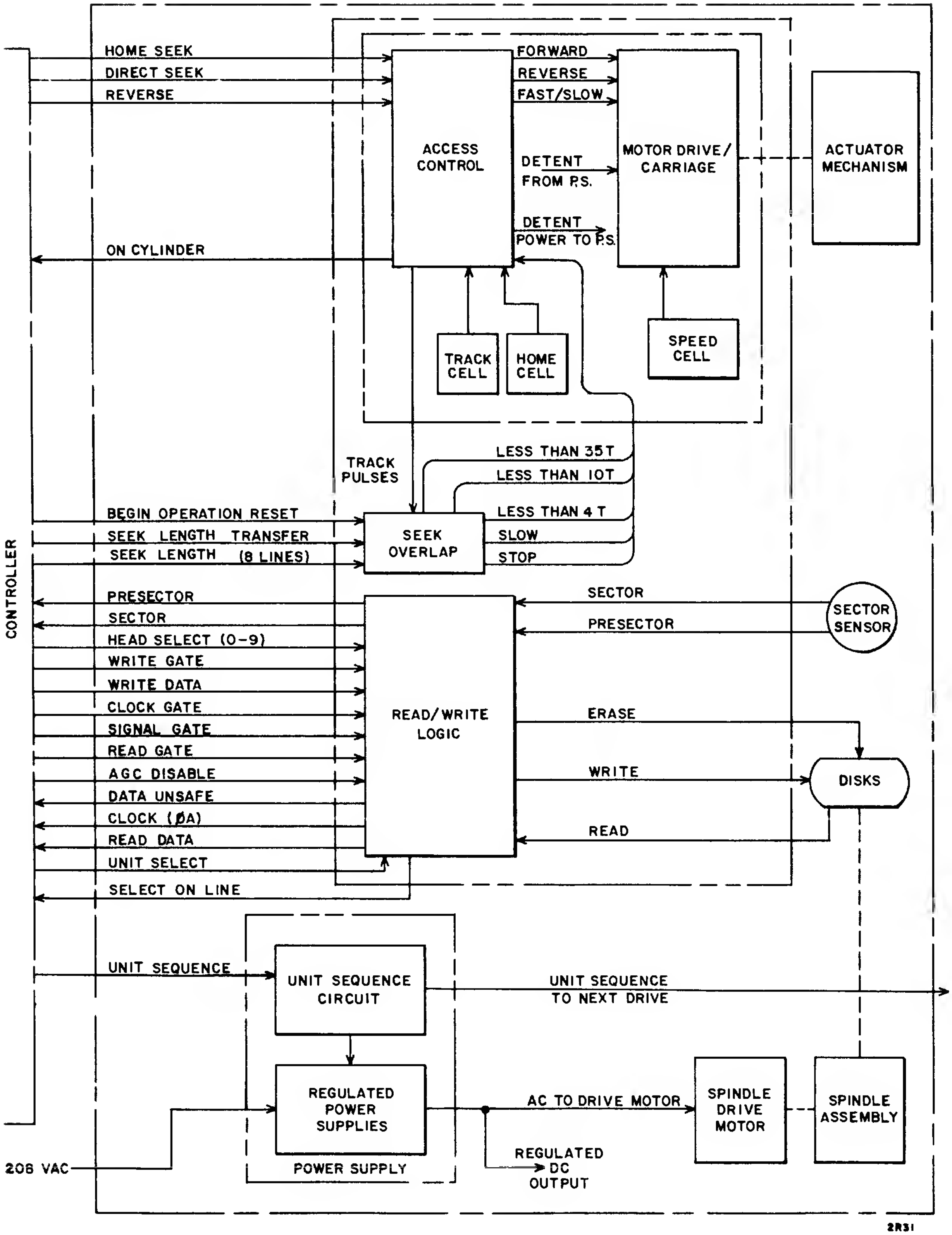


Figure 2-2-1. General Block Diagram

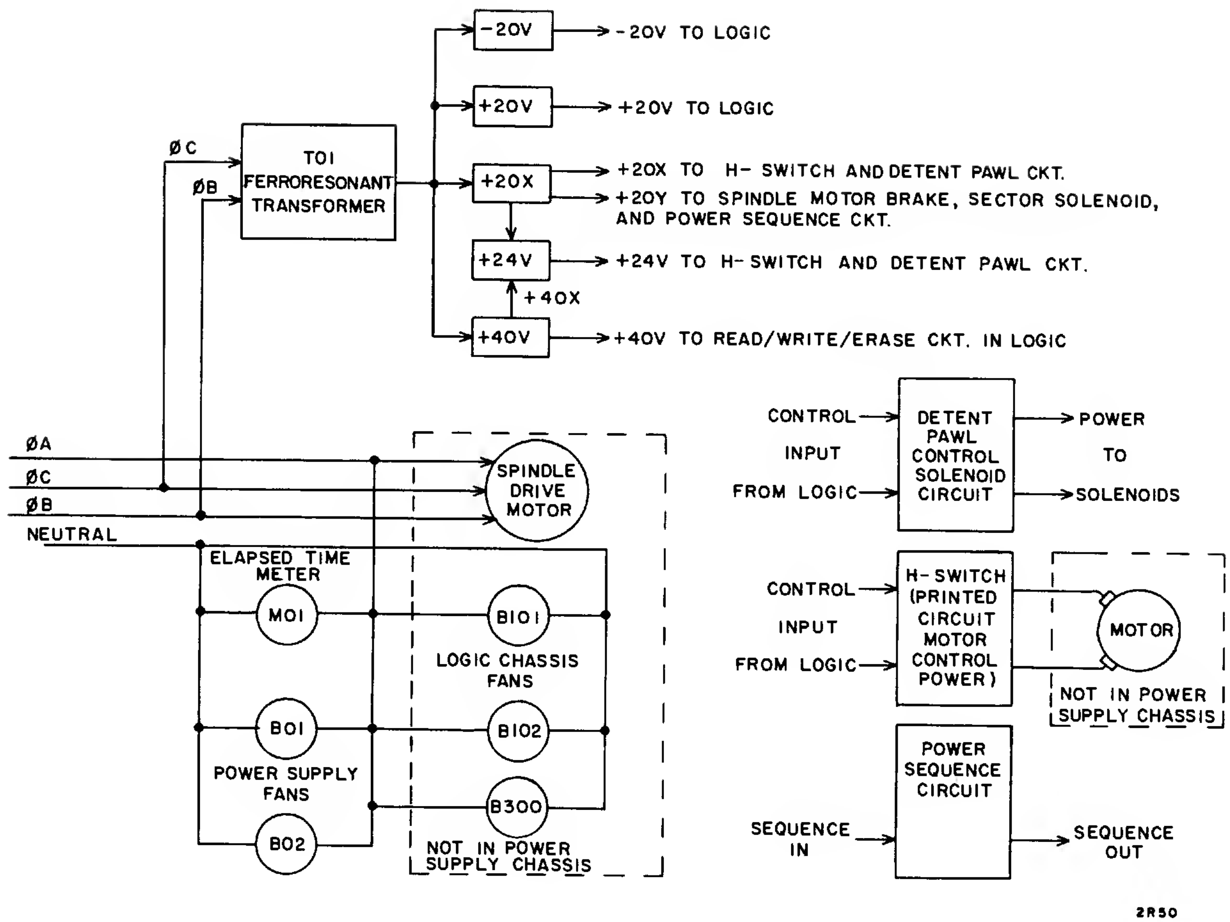


Figure 2-2-2. Power Supply, Block Diagram

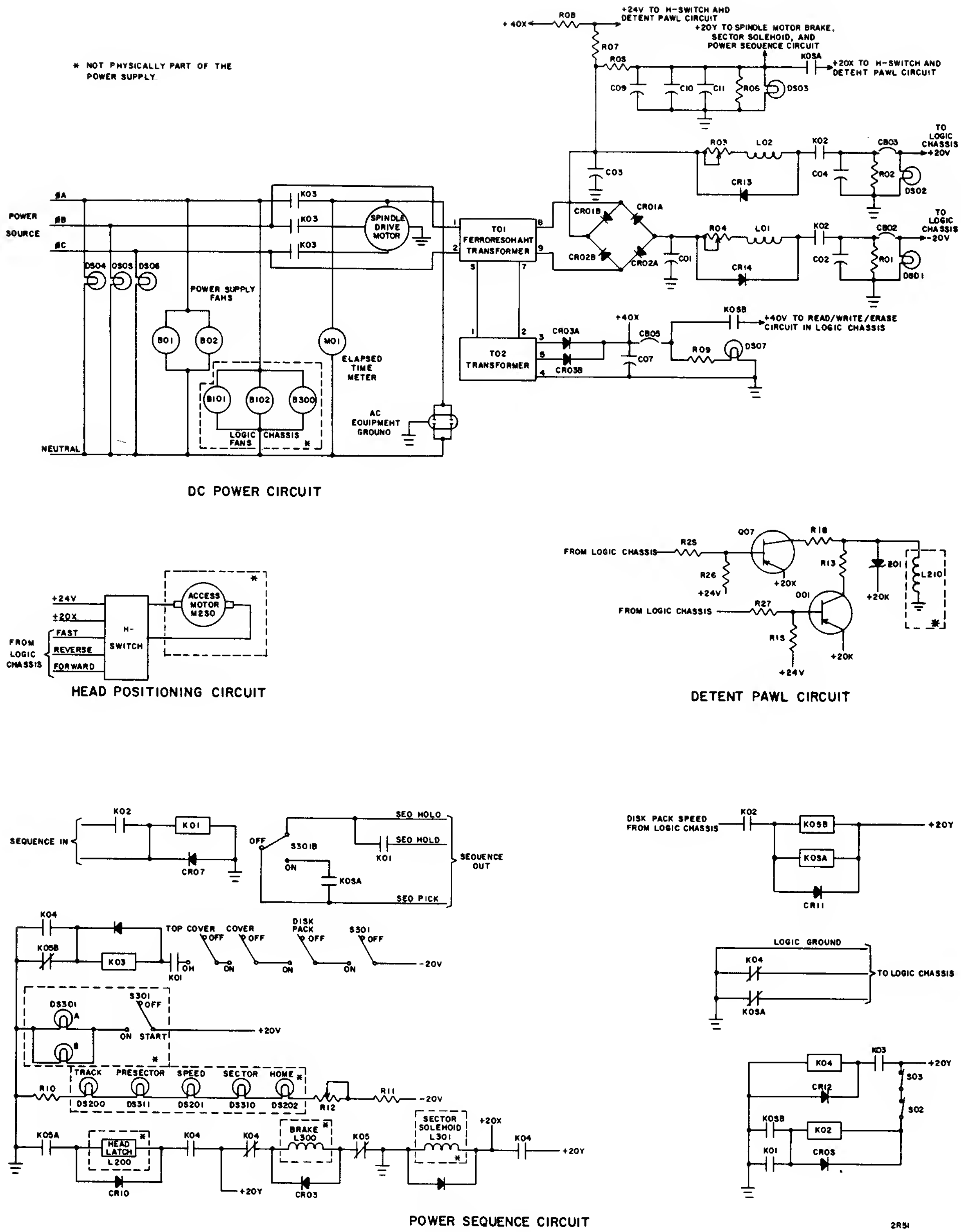


Figure 2-2-3. Simplified Schematic

The +20 volts dc developed across capacitor C03 is also applied to the junction of resistors R07 and R05. Resistors R08 and R07 form a voltage divider. With +40 volts dc applied to resistor R08, the junction of resistors R08 and R07 is driven to approximately +24 volts dc. This voltage is applied out to the "H" switch and detent circuit for transistor bias. The +20X volts at the junction of R07 and R05 is applied to filter capacitors C09, C10, and C11. Resistor R06 is a bleeder to remove the charge from the capacitors once the unit has been turned off and power is removed. Indicator DS03 provides an indication that the +20X volts is available.

Transistors Q01 and Q07 are used to pull the spring loaded pawl out of the detent gear. Transistor Q07 provides an initial high current pulse of 15 amps for 4 msec, which is needed to pull the detent pawl. This 15-amp pulse is applied 2 msec longer than required, to prevent the spring loaded pawl from bouncing out of the detent solenoid. Transistor Q01 is also gated on at the same time. Q01 is left on until the detent command is received. The current through Q01 flows through the 10-ohm resistor (R13) to provide approximately 2 amperes holding current to the solenoid. Once the detent command is reached, power is removed from the base of Q01, allowing the spring-loaded pawl to be pulled into and engage the detent gear. Approximately 2 msec are required, after Q01 is gated off, to engage the gear.

Printed Circuit Motor Motion Control

The printed circuit motor, which moves the carriage drive and positioning mechanism, is controlled by a five-transistor switching circuit in the power supply. By controlling the transistor selection and the amount of current through these transistors, the motor is driven fast or slow in the reverse or forward direction. Transistors Q03 and Q06 are switched on for a forward operation, causing the printed circuit motor to drive the carriage forward. Transistors Q04 and Q05 are switched on for a reverse operation, connecting the switching circuit in such a manner as to allow motor current flow in the reverse direction.

The five transistors (Q02 through Q06) are normally gated off by the +24 volts dc applied through a resistor to the base. Emitter voltage, applied to the PNP transistors, is supplied by the +20X voltage source. The base bias voltage is greater than the applied emitter voltage, to assure that the transistors are cut off when not selected. When a move co mmand is applied, the base resistors complete a voltage divider, resulting in a forward biased transistor.

Resistors R29 and R31 prevent overdrive of transistors Q03 and Q05 respectively. This prevention allows the amplifier card inputs to the switching circuit, to drive both switching transistors (Q05 and Q04 or Q03 and Q06) in parallel even though the emitter reference voltages are different. The value of R29 and R31 are selected to provide equal drive to the parallel switching transistors.

The magnitude of current in the printed circuit drive motor is determined by the power supply voltage, and the total effective series resistance in the circuit. The voltage supplied to the switching transistors is fixed, but the

total circuit resistance during the high current drive, excluding the saturation resistance of the switching transistors, is approximately 2.5 ohms. After the current is reduced, the total circuit resistance is approximately 15.5 ohms. The use of series resistor R17 during slow speeds, and while the carriage is stopped, prevents excessive current and motor torque when not needed. Circuit breaker CB07 prevents sustained high-level currents from damaging the printed circuit motor.

Power On Sequence

Sequencing of the power within the power supply is accomplished by six relays. This sequencing is necessary to prevent destruction of heads and/or disks and to assure proper control of the actuator mechanism by the logic.

Motor sequence relay K01 is energized when the unit receives a sequence in from either the control unit or the previous storage drive on the line. Sequencing of the storage drives is necessary to prevent loading of the primary power source.

If this disk drive unit Start switch is not lighted (S301 is in OFF condition), the sequence out level is applied to the next storage drive.

Assume that a power on command is received from the control unit and the Start switch (S301) is lighted. The +20Yvdc is applied through connector J08 to complete the path and energize relay K01. When relay K01 is energized, contacts 1 and 7 close to energize relay K02. When K02 is energized, contacts 3A and 3C close to supply +20vdc to the logic chassis, and contacts 4C and 4A close to supply -20vdc to the logic chassis. Relay K02 contacts 2A and 2C also close allowing power to be applied to relays K05A and K05B when the motor is up to speed.

Relay K01 also completes the path through contacts 3 and 9, to energize relay K03 when the disk pack is on, both top covers are closed, and the Start switch is lighted. With relay K03 energized, contacts 4A and 4C close, contacts 3C and 3A close, and contacts 2C and 2A close to apply power to the spindle motor.

With relay K03 energized, contacts K03-1A and 1C are closed to complete the path to energize relay K04. Once relay K04 is energized, relay K03 is maintained energized through closed contacts 1 and 7 of K04. Relay K04 contacts 1 and 4 open to apply an output signal indicating that the motor is on. Contacts 2 and 8 of K04 close, allowing power to be applied to the head latch when the disks are up to speed. As K04 contacts 2 and 5 open, the spindle brake is released.

When the disk pack is up to 70 percent of the rated speed, the logic completes a circuit to energize relays K05A and K05B, through J03-X. When relay K05 is energized, the following events occur:

1. +20vdc is supplied to the H switch and detent circuit.

2. +40vdc is applied to the read/write circuit.

3. When contacts 2 and 5 of K05A are opened, a signal is applied to the logic indicating that the pack is up to speed. This signal is applied to a 15-second delay card, which allows time for the air to be purged from the disk pack area before loading the heads.

4. Contacts 2 and 8 of K05A close to apply power to the head latch. Once the heads are l oaded, the solenoid armature holds the heads loaded.

5. Holding current is supplied to hold relay K02 energized.

Power Off Sequence

Power in the disk storage drive can be cycled off in any of three ways: from the Start switch on the disk storage drive operator control panel, by opening either top cover, or from the control unit. It will be assumed that the purpose for this power off sequence is to change packs. The sequence is initiated when Start switch S301 is depressed, opening the contacts of S301A, and breaking the circuit holding relay K03 energized. Relay K03 is de-energized, removing power to the spindle motor and causing the pack to slow down. Also, when K03 is de-energized K04 is de-energized, closing contacts 2 and 5 in series with the brake. Brake power is not applied, however, until relay K05B is de-energized. Contacts 4 and 1 of K04 close to indicate that the motor is off. Contacts 8 and 2 of K04 open causing the head latch to drop and unload the heads. As the pack speed decreases to 70 percent of the rated speed, with the brake off and heads unloaded, the detent is pulled and the heads are retracted at 2 inches per second. When the motor speed is reduced, relays K05A and K05B are de-energized through the speed sensor logic. Also, K05B contacts 1 and 4 close to apply brake power to the spindle. The total time of the power off sequence is approximately 10 seconds. If something occurs, to prevent contacts 2 and 8 of K04 from removing the latching current to the head latch, contacts 2 and 8 will open when K05 is de-energized to assure that the heads do not crash into the disk surface as the pack slows to a stop. Relay K05 also removes the power (+40vdc) to the read/write circuit, and removes the +20Xvdc to the "H" switch transistors to prevent driving of the actuator in either direction.

When the plexiglass cover is opened, the cover-on switch (S303) is opened to prevent the initiation of the on sequence until the cover is closed.

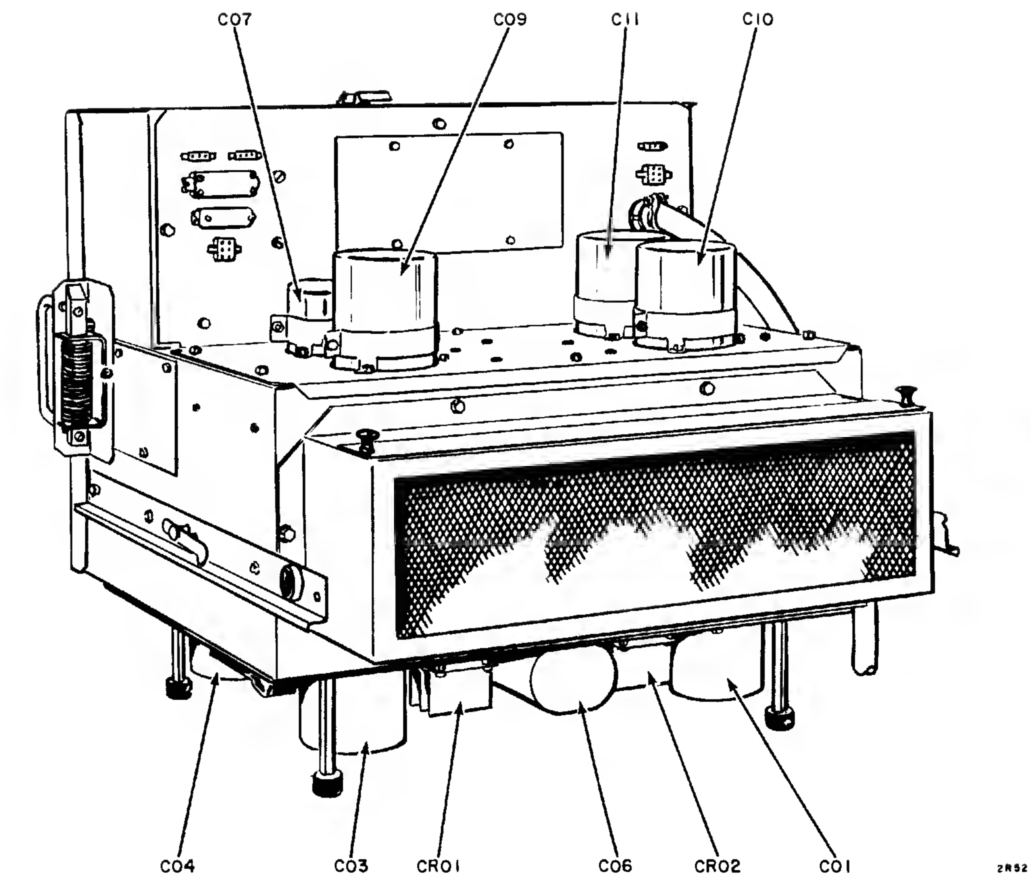


Figure 2-2-3. Power Supply, External Rear View

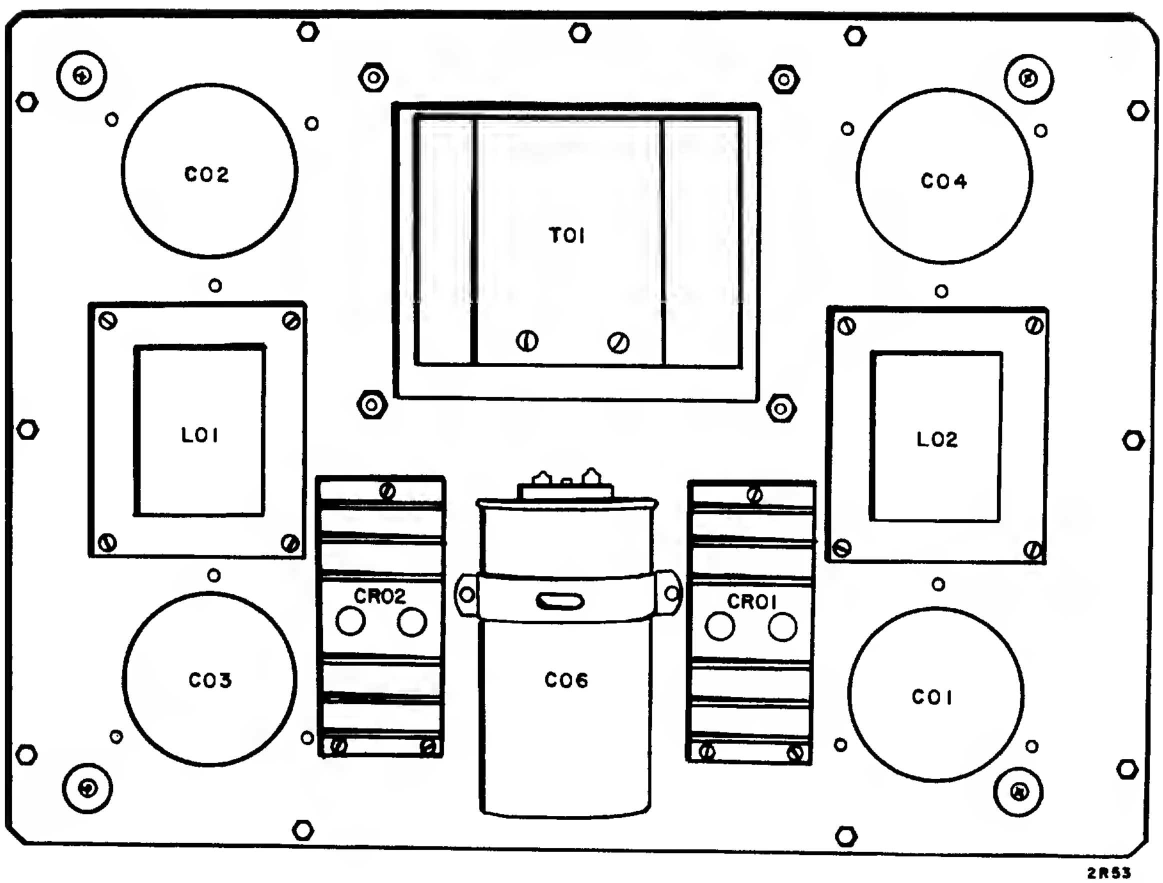


Figure 2-2-4. Power Supply, Bottom External View

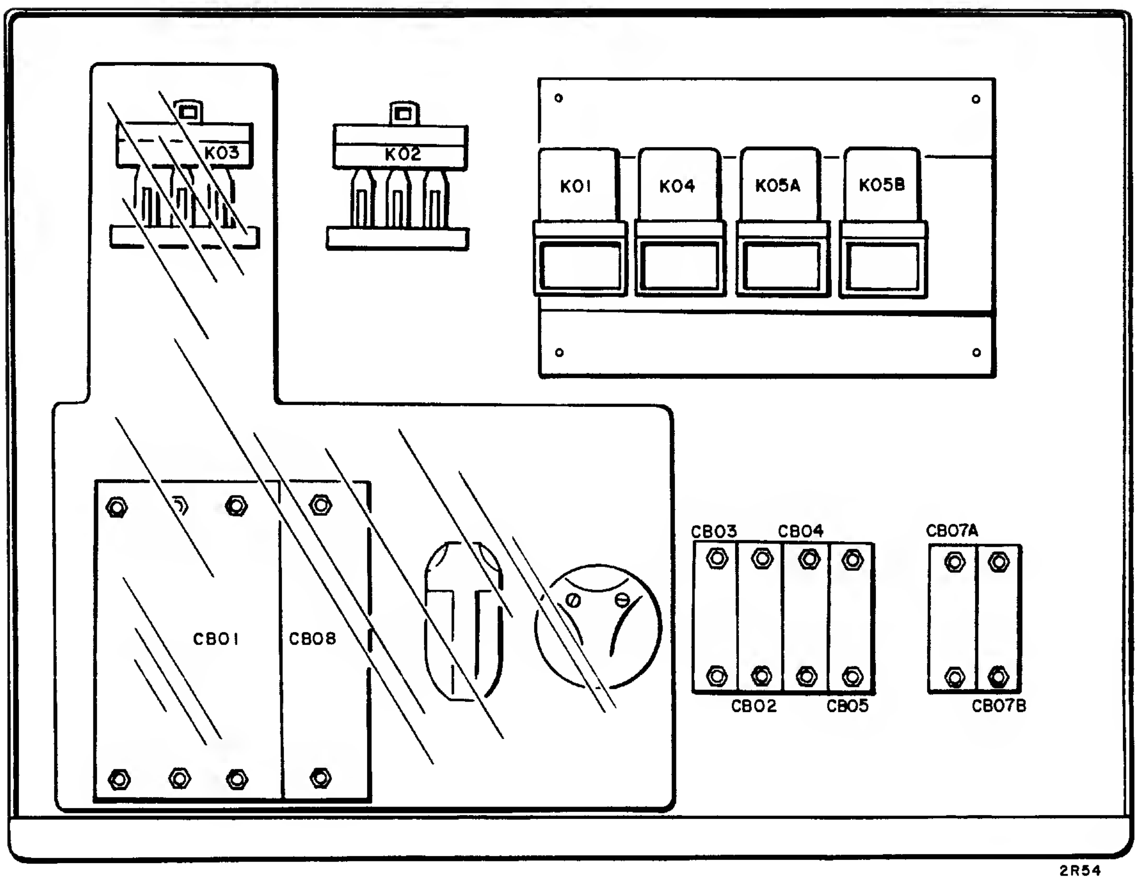


Figure 2-2-5. Power Supply, Rear Front Panel

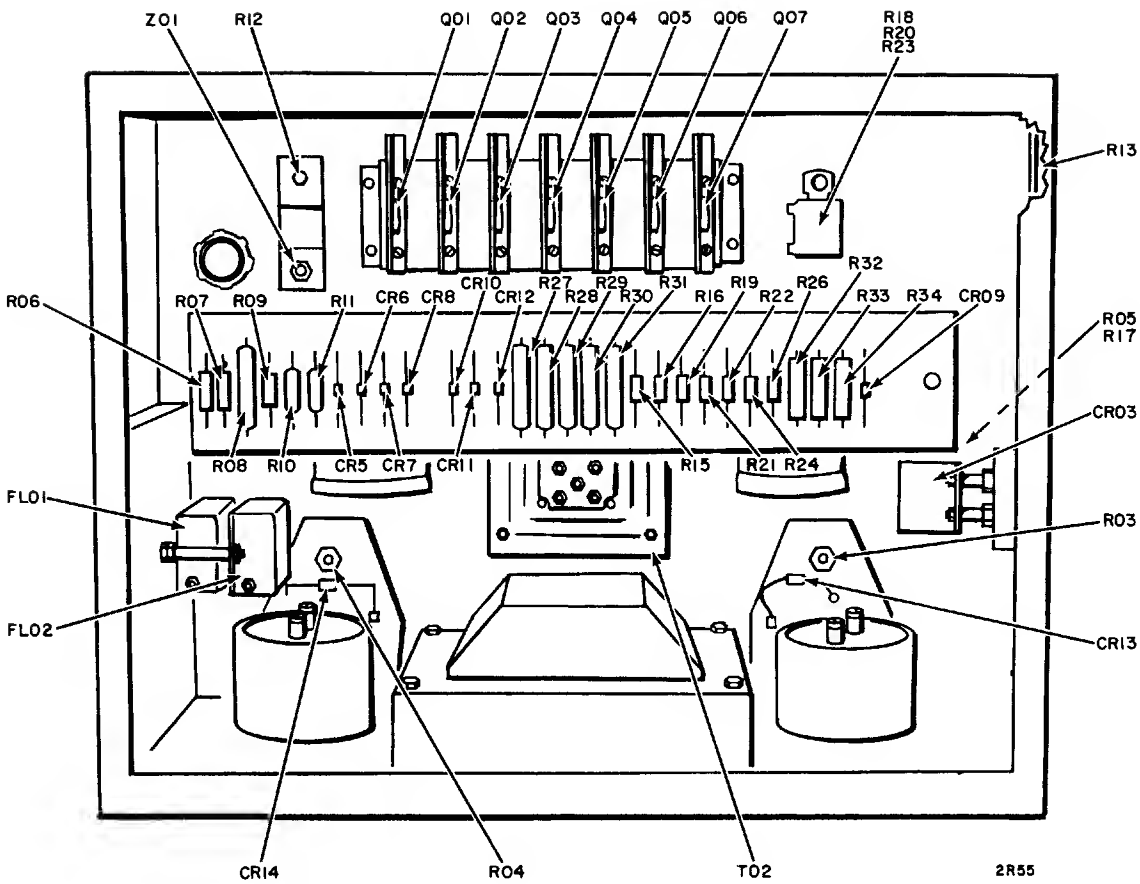


Figure 2-2-6. Power Supply Chassis

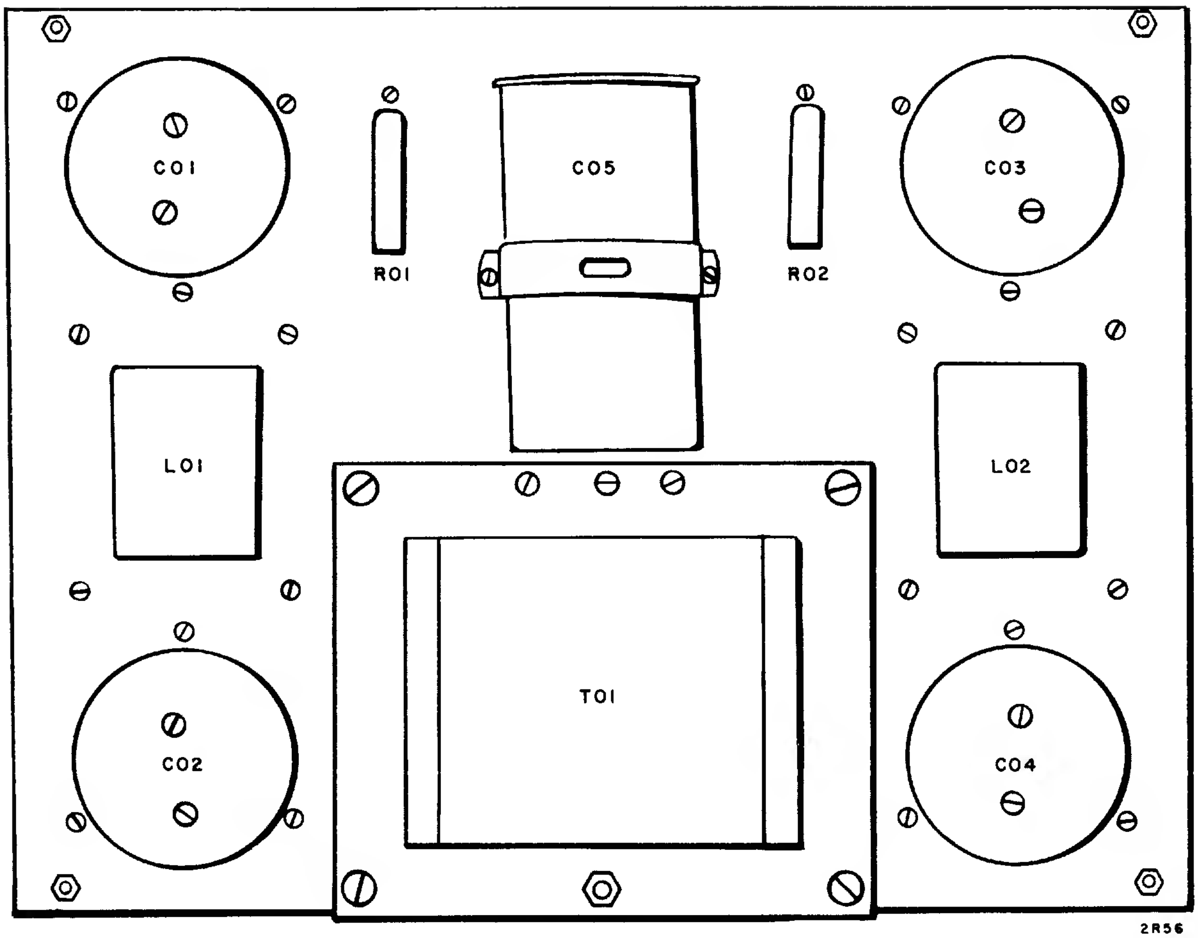


Figure 2-2-7. Power Supply, Internal Bottom View

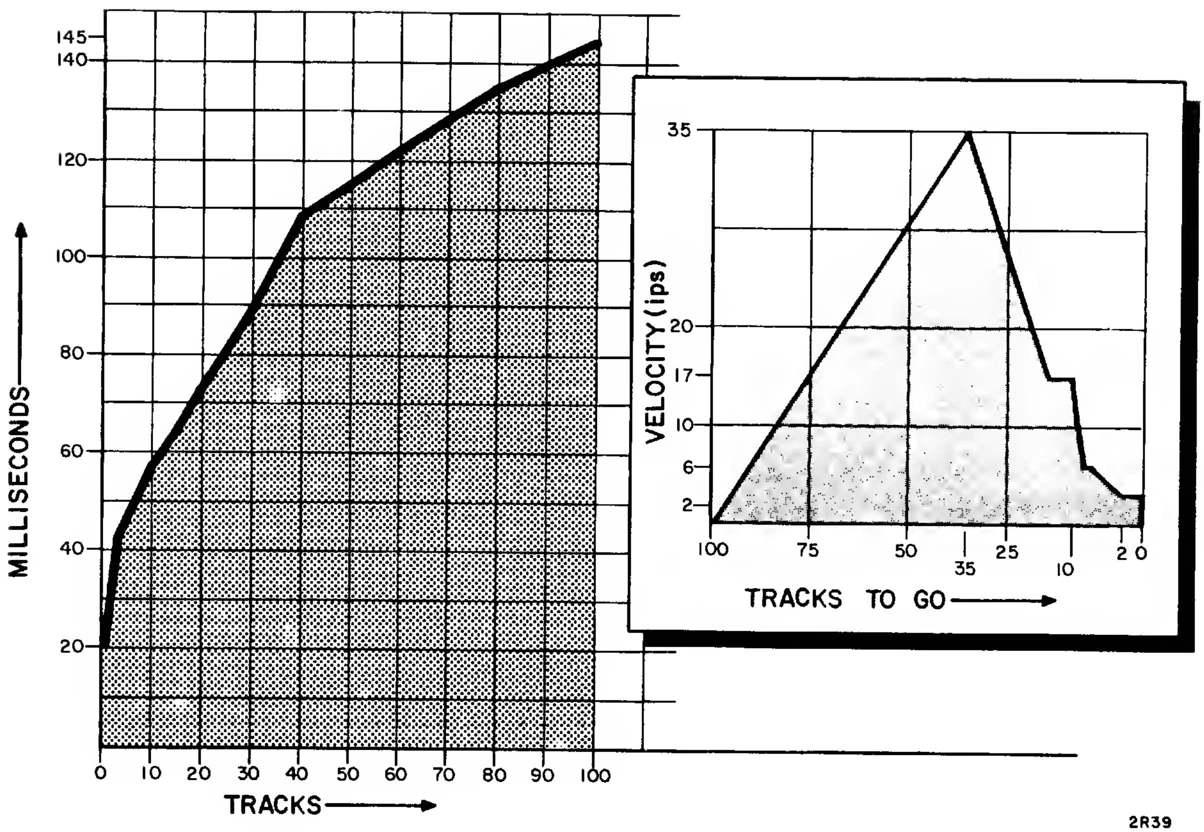


Figure 2-2-8 .. Forward Speed and Access Curves

ACCESSING LOGIC

GENERAL DESCRIPTION

The accessing logic establishes the position of the read/write heads and the carriage by controlling two units which are part of the actuator.

First, the accessing logic controls the carriage detent. When the detent solenoid is energized by the accessing logic, the detent pawl is disengaged from the detent gear and the carriage is free to move. When the detent solenoid is de-energized, the detent pawl is engaged with the detent gear and the carriage is locked into position.

Secondly, the accessing logic controls the carriage drive motor. When the motor is energized the carriage is moved. The detent pawl is disengaged from the detent gear when the drive motor is energized. When the carriage has moved to the proper position, the current to the motor is momentarily reversed to dynamically brake the carriage to a complete stop.

The accessing logic has four normal modes of operation: first seek, direct seek, return-to-home seek, and power off seek. There are also two error recovery seeks: the forward seek error, and the reverse seek error.

The first seek is part of a power up sequence and the purpose is to load the heads and position them at track 00.

The direct seek is the normal method of positioning the heads at the desired track. The computer program must determine the number of tracks and direction that the carriage must be moved to bring the heads to the desired track.

The return-to-home seek is used when the computer program cannot determine the proper number of tracks to a requested track. For a return-to-home seek, the number of tracks is determined by the accessing logic but is a much slower operation since the carriage is always returned to track 00 to start this operation.

The power off seek is part of the power down sequence and its purpose is to return the heads to the retracted position.

A seek error occurs when the accessing logic is requested to move the R/W heads beyond the normal recording area --tracks 00 thru 99. This can occur only on a direct seek and is generally a computer program error.

FIRST SEEK

General Description

The disk pack is allowed to rotate for 12 seconds after power up to purge dust from the disk surfaces.

At the end of the 12 seconds, the first seek operation is initiated. This will cause the carriage to move forward at six inches per second. The cam follower, which is connected to the carriage, moves forward on the heads loading cam and rotates the torsion springs. When the cam rotates a full 60 degrees, the heads-loaded latch drops into place and locks the torsion rod into position. The heads-loaded latch also transfers the heads-loaded switch at this time. When the heads-loaded switch transfers the cam latch is released and the carriage motion is reversed. This occurs at about track 75. The carriage will continue to move in reverse at 2 inches per second until home is sensed. At this time the carriage motion is changed to forward and will continue until the carriage moves forward one track which will be track 00. The stop circuitry dynamically brakes the carriage to a complete stop and allows the detent pawl to engage the detent gear and lock the carriage in this position.

20 milliseconds after the carriage is stopped, an on-cylinder signal is generated which terminates the first seek operation.

Detailed Description

The first seek is initiated by setting the First Seek flip-flop (K200/201).

The pin 2 AND gate will set First Seek for a normal power up sequence. The pin 1 gate will set First Seek for a forward seek error and recovery.

The pin 2 AND gate is made as a result of the disk pack reaching 1200 RPM and causing 1204 to output a "1".

Disk Pack Speed Detection

I224, &208, and I266 form a 50 msec leading-edge-pulse network for the sector pulses. When the sector pulses reach a rate of about 400 PPS, at 1200 RPM, the output o f the JAE (L202) will switch from -20 volts to ground. This will energize K05 and give an open input to the OJB (Y205), causing the output of Y205 to switch from a "1" to an "0", after the 12-second delay.

First seek sets Forward (K206/207) which enables the forward accessing circuits. The first seek also generates an Any Seek from I218 which clears Stop (K208/K209) and Detent (K212/K213). When Detent clears, a "0" is fed into the 4 msec delay, Y312. During the 4 delay, L200 and L201 switch from +20 volts to ground and drive the hold and pick power transistors which energize the detent solenoid. The pick is terminated at the end of the 4 msec delay.

Clearing Detent also causes the On Cylinder signal to drop, which allows the gate into L300 to be made. The output of L300 then switches from +24 volts to ground which turns on transistor switches Q03 and Q06. This drives the access motor in the forward direction.

The AND gate into L300 is controlled by the forward servo (I305) and the reverse dynamic brake (I306).

I305 is enabled when Forward (K206/K207) is set. The pin 1 input will limit the carriage to 6 inches per second when Slow (K210/K211) is set. Pin 3 input will limit the speed to 20 inches per second when fewer than 35 tracks remain to go. Pin 4 will limit the speed to 2 inches per second when fewer than 4 tracks remain to go, except during first seek.

Carriage Velocity Detection

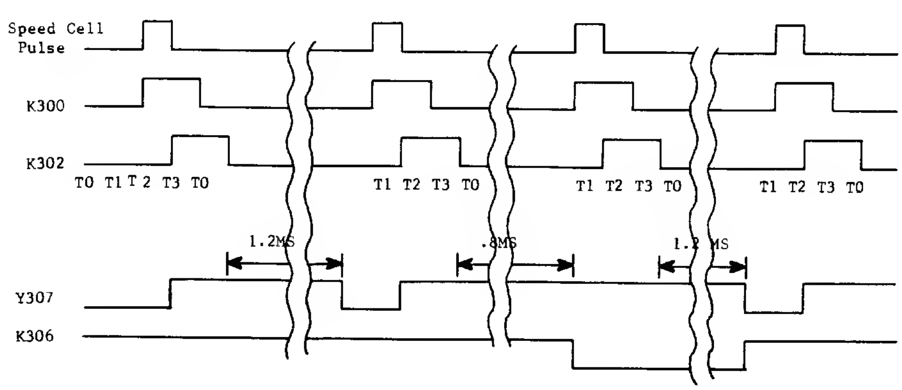
The track count is translated from the seek length counter which is held clear during first seek. This provides a track-to-go translation of "0". The seek length counter operation will be explained in the direct seek description.

The carriage velocity is determined by measuring the time between pulses from the speed cell. When the speed cell senses light from the timing disk, the emitter approaches +20 volts which causes Y321 to switch from a "0" to a "1" and Y322 to switch from a "1" to a "0". A 4 leading-edge pulse from Y321 is used to start the speed cell timing chain. T1 will clear the speed flip-flops (K306/K307, K308/K309, K310-K311) if the output of their respective delays (Y307, Y306, Y305) are outputting "1"s.

T2 arms and T0 will start the delays. If a T1 occurs within 1 msec after K306/K307 will be cleared indicating that the carriage is moving faster than 2 inches per second.

If T1 occurs within 0.33 msec after T0, K308/K309 will be cleared, indicating that the carriage is moving faster than 6 inches per second. If T1 occurs within 0.1 msec after T0, K310/K311 will be cleared, indicating that the carriage is moving faster than 20 inches per second.

If T1 does not occur within the delay period, the delay will time out and set the respective speed flip-flop.



CARRIAGE SPEED TIMING

The controlling term for forward motion on first seek is the pin 1 input to I305. Slow (K210/K211) is set by A105 which is a "1" when the seek-length counter is held clear during first seek. Forward drive will be maintained until the carriage velocity exceeds 6 inches per second and K308/K309 is cleared. With all "1's" into the pin 1 AND gate of 1305, 1315,will output a "0" and terminate forward drive. The carriage will then coast until it slows to less than 6 inches per second, which will allow K308/K309 to set and again cause forward drive. This will cause the carriage to servo around 6 ips.

This forward motion will continue until the carriage extends far enough to rotate the torsion rod 60 degrees and the heads-loaded latch engages and transfers the heads-loaded switch. This occurs at about track 75.

Max Drive Circuit

Additional torque is required from the access motor during first seek to operate the head loading mechanism. This additional torque is generated by the max drive circuit.

First seek enables the pin 7 clear input to K312/K313 giving a "0" from the set side and enabling the AND gate to L302 through L317. This causes L302 to output a ground which turns on transistor Q02. Q02 bypasses R17 and provides additional current to the access motor which generates maximum torque.

When the heads loaded switch transfers, the pin 7 clear AND gate of K206/K207 will clear Forward. This will disable the forward accessing circuits and enable the reverse accessing circuits. Reverse is controlled by the AND gate into L301. With all "1's" into the AND gate, the output of L301 switches from +24 volts to ground, which turns on transistors Q04 and Q05 and provides reverse drive current to the access motor.

The AND gate into L301 is controlled by the reverse servo (I309) and the forward dynamic brake (I310).

1309 is enabled when Forward is clear. Pin 7 limits the reverse carriage speed to 2 ips when fewer than 4 tracks remain to go, except during a return-to-home seek or when fewer than 10 tracks remain to go. Pin 10 limits reverse carriage speed to 20 ips when fewer than 35 tracks remain to go.

The controlling term for reverse motion during first seek is the pin 7 input to 1309. This term will cause the carriage to servo around 2 ips in the reverse direction. The reverse motion will continue until the carriage reaches the home position (track -1).

When the home cell is detected at track -1, a "1" is generated from Y241 which clears First Seek by making the AND gate on pin 7 of K200/K201. This enables 1203 to generate track pulses when they are detected by the track cell.

Forward is also set when home cell is detected by making the AND gate at pin 3 of K206/K207. When Forward sets, the reverse access circuits are doubled. L305 outputs a "1" and causes forward drive to the carriage. As the carriage moves forward, a track pulse will be generated from Y243 which will set stop (K208/K209).

If the seek length counter is zero, A103 will output a "1" and allow a track pulse to set stop by making the AND gate on pin 2 of K208/K209, except when first seek or RTHS are set.

Stop will be set by track pulse from track 0. A trailing-edge network will set detent when the track pulse drops, by making the AND gate on pin 2 of K212/K213 for 4 msec. When detent is set, a stop operation is initiated.

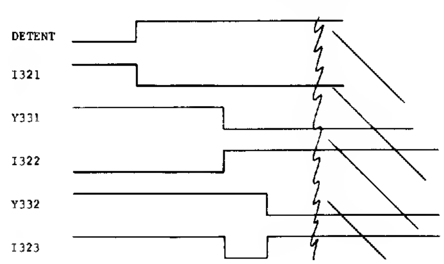
L200 outputs +24 volts which turns off Q01 and de-energizes the detent solenoid. This allows the detent pawl to engage the detent gear. About 6 msec is required for the detent pawl to fully engage the detent gear.

The detent flip-flop also initiates the stop circuits by making the AND gate into 1321, which starts the 4 msec delay Y331. This delay allows the notch of the detent gear to move to the center of the detent pawl. When Y331 times out its output goes to a "0" which starts the 2 msec delay &332. The "0" from Y331 also breaks the gate into 1322. During the delay of Y332, 1322, and 1320 are outputing "1's" which will make the AND gate into 1323 and generate a 2 msec stop signal.

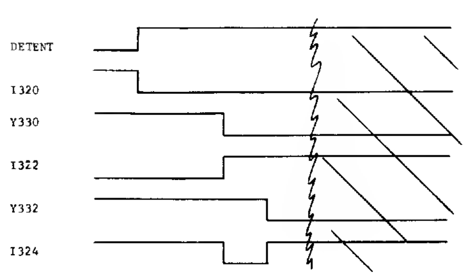
1323 breaks the AND gate into L300, 1316, and 1317, which will generate a max drive dynamic brake to stop the carriage.

When the 20-msec delay (Y203) and the 200-msec delay (Y220) time out, an On Cylinder signal is generated which indicates to the controller that the disk drive is ready for operation.

FORWARD STOP TIMING



REVERSE STOP TIMING



DIRECT SEEK

General Description

When it is necessary to move the R/W heads to a different track to access a new block of storage, a seek operation is initiated by the disk drive controller. There are two types of seek operations. The direct seek and the return-to-home seek. The direct seek is most often used as it is much faster than RTHS.

To perform a direct seek, the controller sends the seek length (number of tracks to go), the direction, forward or reverse, and the direct seek command to the selected disk drive unit. Upon receipt of these signals the disk drive access logic causes the carriage to move at the max rate in the proper direction. When the carriage moves, track pulses are generated as each track is crossed. Each track pulse will decrement the seek length counter. The carriage speed will be reduced in steps as the seek length counter approaches zero. When the seek length counter reaches zero, the carriage is brought to a complete stop and, after a 20 msec delay, an On Cylinder signal is returned to the disk drive controller indicating that the seek operation is complete.

Detailed Description

If the heads are loaded and the maintenance switch is set to "on line", when the select unit number zero is received from the controller by M012, a Unit Selected signal is returned to the controller by T000. When the controller receives this signal, it can initiate operations on disk drive 0.

When the controller initiates a direct seek, four signals and 8 bits of information are transmitted to the disk drive. The first signal which is received by the disk drive, at R111, which is an inverted receiver, is the Begin Operation Reset. This clears the seek length counter. The second signal is the Seek Length Transfer which is received by R110, also an inverted receiver. This signal gates the 8 information lines containing the seek length, into the seek length counter. The third signal is Reverse, which will be received by R201. The Reverse signal will set the Reverse flip-flop (K214/K215). Forward is indicated by the absence of the Reverse signal. The fourth signal, which is received at the same time as Direction, is the Direct Seek Command, relieved by R204. R204 generates an Any Seek from F218. This signal initiates motion by clearing the stop FF and Detent FF K212/213. When detent is cleared the On Cylinder signal is dropped to the controller and will not come back until 20 msec after the seek operation is completed.

Seek Length Counter

A maximum direct seek is 99 tracks, forward from track 0 to track 99 or reverse from track 99 to track 0. The maximum count which can be contained by the seek length counter is also 99. The seek length

counter is a BCD counter using the 5-4-2-1 BCD format. When the counter contains a full count of 99, the following flip-flops will be set in Rank 1; A020/021, A030/031, A060/061, and A070/071. The counter will decrement when the carriage moves and track pulses are generated. Decrementing is controlled by the counter timing chain (K100/101 and K110/111). The timing chain is started by a trailing-edge pulse generated when track pulse drops. T1 causes Rank I to be gated to Rank II.

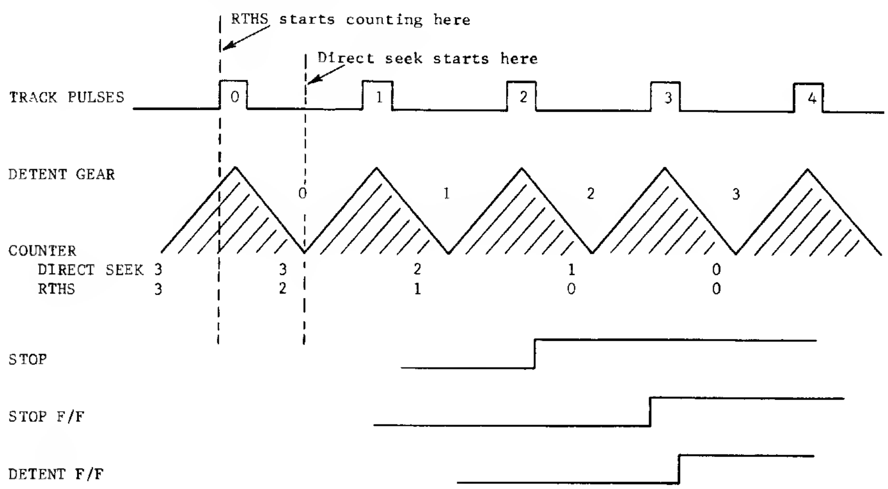
When the Seek Length Transfer is received by R110, A905 outputs a "1" to load the seek length into Rank I. A100 also outputs a "1" which starts the timing chain at T2. When the timing chain advances to T3, the new seek 1 ength is transferred from Rank I to Rank II. T1 is bypassed to prevent decrementing Rank I during this loading operation.

The counter is translated in 4 steps. The first step is at track count less than 35. This translation will cause A108 to output a "0". The second step is at track count less than 10. This translation will cause A105 to output a "1". The third step is at track count less than 4. This causes A107 to output a "0". The fourth step is stop. When doing a RTHS, A103 will output a "1" when the track count is zero. When doing a direct seek, A103 will output a "1" when the track count is "1". The reason for this difference can be seen in the following timing chart.

RTHS always starts counting from home cell and the first count will be when the 0 track pulse is detected.

Direct seek always starts counting from its present location. If a direct seek starts from track 0, the first track pulse which is detected will be the 1 track pulse.

The counter will always go to zero, one track sooner during a RTHS than during a direct seek.



DETENT TIMING

When Detent is cleared by the Direct Seek command, the detent solenoid is energized and the carriage is free to move. When the 4 msec detent pick delay (Y312) times out, K312/313 will be held clear for 5 msec by the delay Y313. This will generate max drive to the access mo tor to provide a high rate of acceleration to start the carriage. If there are more than 35 tracks to go, K312/313 will remain cleared and the carriage will continue at high acceleration. During a maximum move of 99 tracks, the carriage reaches a velocity of about 35 ips.

L300 and L301 control the direction of the carriage movement. If Forward is set, the forward servo (L305) and the forward dynamic brake (L310) are enabled. As long as more than 35 tracks remain to go, L305 will output a "1" providing constant forward drive. When track count reaches less than 35, the pin 10 And gate to L310 will be made to provide dynamic braking and slow the carriage to 20 ips. When L310 outputs a "0" the AND gate into L300 will be broken, terminating forward drive. L316 will make the AND gate into L301, providing reverse current to the access motor. This causes maximum deceleration of the carriage to 20 ips. As soon as the velocity reaches less than 20 ips, L310 will output a "1" snd allow forward drive which will again accelerate the carriage to more than 20 ips. This causes L310 to output a "0" and terminate forward drive and again initiate reverse drive to decelerate the carriage to less than 20 ips. This action causes a tight servo loop in the forward direction at 20 ips.

A second plateau is reached when less than 10 tracks remain to go. A105 will set Slow (K210/211), which will clear K312/313 at pin 8, and provide max torque to slow the carriage down to 6 ips. Slow will also enable the pin 9 AND gate of L310 to generate the reverse current needed to dynamically brake the carriage to 6 ips. When 6 ips is reached, K312/313 will set to terminate max drive and K304/305 is cleared to terminate dynamic braking. The pin 1 input to L305 will cause the carriage to servo around 6 ips. When the gate is broken, L305 will output a "1" and cause forward drive. When the carriage accelerates above 6 ips the AND gate will be made, terminating forward drive and allowing the carriage to coast. The carriage will slow down as it coasts and, when it slows to less than 6 ips, L305 will output a "1" and again turn on forward drive. This action causes a loose servo loop in the forward direction at 6 ips.

A third plateau is reached when the track count is less than 4. This will generate a 4 msec "1" froml311 which will set Permit Dynamic Brake (K304/305), making the pin 9 AND gate into .310. The "0" from 1310 will break the gate to L300 which will terminate forward drive. The "1" from L316 will make the AND gate into L301 and turn on reverse drive to dynamically brake the carriage to 2 ips. The reverse current to the access motor is limited by R17 because K312/313 is set at this time. This will cause the carriage to slow to 2 ips at a medium rate of deceleration. When the carriage slows to 2 ips, Permit Dynamic Brake is cleared and the carriage will continue forward at about 2 ips controlled in a loose servo loop by pin 4 of L305.

The Stop command is generated when the seek length counter is decremented to a count of 1. The stop sequence is the same as for the first seek.

Reverse seek sequence is the same as the forward seek. L309 is the reverse servo and L306 is the reverse dynamic brake.

RETURN-TO-HOME-SEEK

General Description

Return-to-home seek is a form of absolute addressing for the disk drive. The seek length counter is loaded with the actual position which is requested, rather than the difference between present position and requested position as with a direct seek. This is accomplished by returning the carriage to home position and initiating a forward seek from this point. The carriage is returned to home at 6 ips. The forward seek portion of the RTHS is the same as a normal forward direct seek.

Detailed Description

The RTHS is initiated by loading the seek length counter in the normal manner. This is followed by the RTHS command which is received by R200 and causes RTHS (K202/203) to set. RTHS (K202/203) will cause L218 to output an Any Seek which will clear Forward (K206/207) and enable the reverse access circuits. Stop (K208/209) and Detent (K212/213) are also cleared by any seek. This will allow the carriage to move. The carriage will move in reverse at 6 ips under control of L309 pin 8. During this return to home, RTHS (K202/203) prevents L203 from generating track pulses so that the seek length counter is not decremented. The carriage will reach home and the seek length counter will still contain the original count. When home cell is sensed, the Forward flip-flop is set and the carriage will begin to move forward. Home cell will also clear RTHS. With Forward set and RTHS clear, the operation reverts to a normal forward seek under control of the seek length counter. Stop will be initiated when the counter goes to zero.

SEEK ERROR

A seek error is generated when a direct seek drives the carriage beyond the normal recording area.

Example: the present position of the carriage is track 50. A forward direct seek of 60 tracks is initiated. The seek error will be sensed as soon as the carriage moves beyond track 99.

Forward Seek Error

If the carriage moves forward to track 100 the home cell will be sensed which will set the Seek Error FF (K204/205) with a 4 msec leading-edge pulse. Seek Error will set the First Seek FF (K200/201) at pin 1. First Seek will clear the seek length counter and the FF Forward (K201/207), which will return the carriage to track 0 as in a normal first seek operation. Seek Error FF (K204/205) will block any further direction seeks. The Seek Error can be cleared by a RTHS or motor power off.

Reverse Seek Error

If the carriage moves in reverse to the track -1, the home cell will be sensed which will set Seek Error FF (K204/205) and the Forward FF (K206/207). When Forward is set, the carriage will begin to move forward and will continue until the seek length counter is decremented to one and generates Stop in the normal manner. The carriage is not automatically returned to track 0 during a reverse seek error as it is during a forward seek error.

POWER DOWN SEEK

A power down seek unloads the heads and returns the carriage to the retract position to enable disk pack removal. The carriage is returned at 2 ips.

Details of Operation

K03 and K04 are de-energized when power is turned off at the operator panel. With K03 de-energized the disk pack will coast to a stop. De-energized K04 will release the heads-loaded latch to unload the heads. The heads-loaded switch will sense when the heads are unloaded and initiate the power down seek by causing 1208 to output a "1". 1208 will clear the Forward FF (K206/207 pin 9) which will enable the reverse access circuits. L208 will also clear the Stop and Detent FFs, which will allow the carriage to move. L309, pin 7, will control the reverse carriage motion at 2 ips. Carriage motion will continue until it comes to the mechanical stop. Carriage drive will continue until disk pack speed drops below 1200 RPM and K05 is de-energized.

HEAD SELECT CIRCUITS

10 read/write and erase heads are provided, one for each of the 10 recording surfaces of the disk pack. The heads are enabled, one at a time,

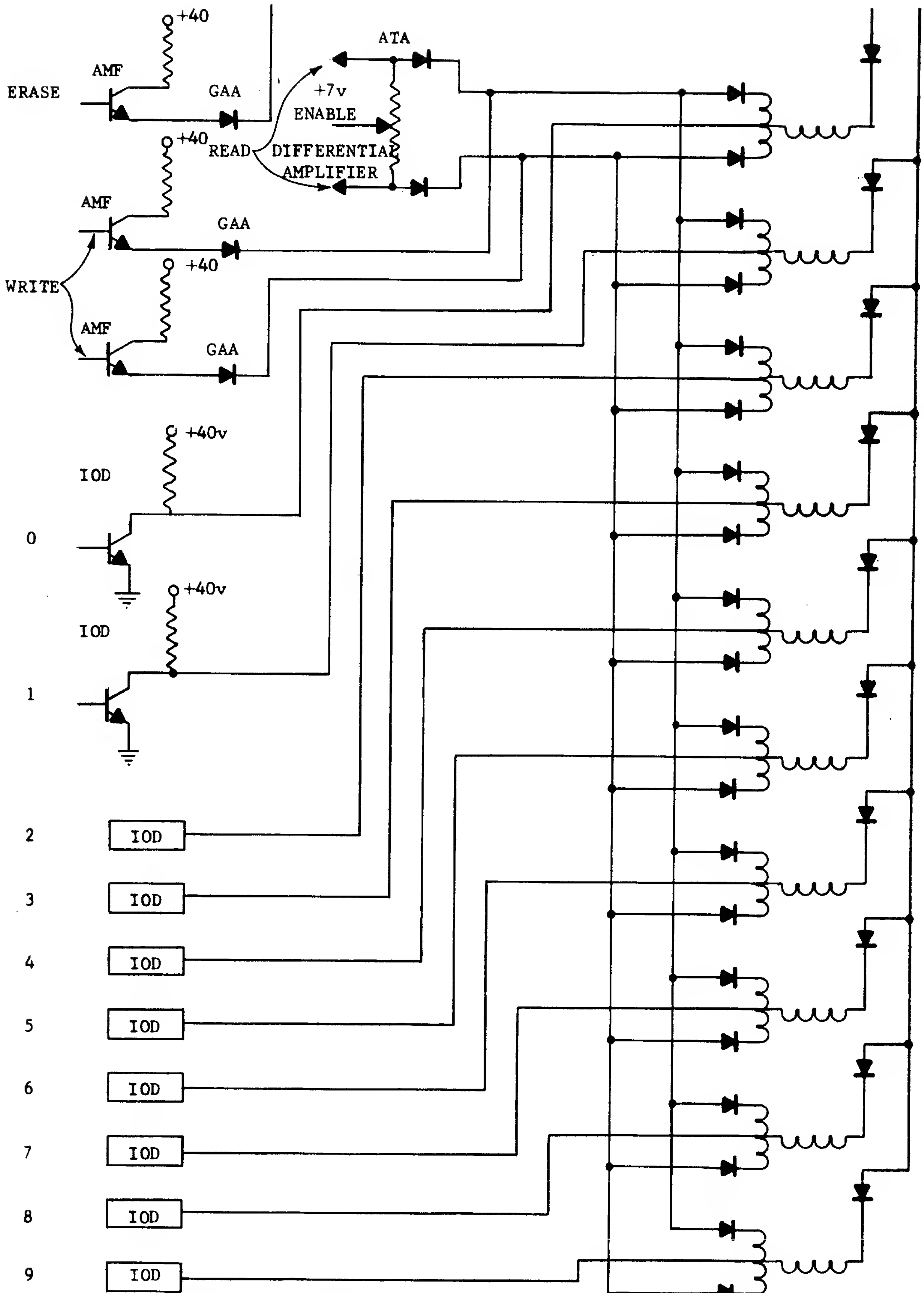
for read or write operations by grounding the center tap of the selected head. Head select is controlled by the disk drive controller and the head address is received at the disk drive by 10 "M" cards (M000--M009). The "M" card outputs a "0" when selected and a "1" when not selected. The Head Select signal is inverted and fed into a head select card (IOD G000--G009). A "1" into the IOD will cause it to output a ground and select the read/write and erase head. A "0" into the IOD will cause it to output +40 volts which will disable the head.

WRITE CIRCUITS

A write operation is enabled upon receipt of a Write Gate signal, which is received by R001. Write Gate will cause I021 to output a "1" and turn on the erase driver (G022). I020 will output a "0" and enable the write toggle (M099). I020 will also break the AND gate into the read/write oscillator (C000) which will turn it on and cause it to generate 700 KC, phase A pulses. The phase pulses are transmitted to the controller by Tool. The phase A pulses are used by the controller to syncronize the data which is sent to the disk drive. Logical "1" data bits are received at the disk drive by R002. Each data "1" bit will toggle the write toggle (M099). This action generates the NRZI recording format. When the write toggle is set, pin 6 will output a "1" and pin 12 will output a "0". When the write toggle is clear, pin 6 will output a "0" and pin 12 will output a "1". G022 is the erase driver and will provide 100 ma for the erase head. G020 and G021 provide 100 ma for the read/write head. A "1" into the AMF causes the output to go to +40 volts and generate head current. A "0" into the AMF causes the output to go to ground and terminate head current.

READ CIRCUITS

A read operation is enabled by the Read Gate and the Signal Gate signals. The read circuits utilize automatic gain control (AGC). A third signal from the controller (AGC Disable) determines when the AGC is enabled. Read Gate is received by R003, Signal Gate is received by R004, and AGC Disable is received by R006, an inverted receiver. Read Gate enables the phase A resync circuits. The Signal Gate enables the first stage read pre-amp (Y031). Signal Gate feeds a "1" into the enable AMP (Y030) which causes Y030 to switch from ground to +7 volts. The +7 volts is fed to a center-tapped resistor contained on Y032. The output of the resistor feeds Y031 pins 5 and 6 which enables amplification of the read signal from the read/write head. The amplified output of Y031 feeds Y032 which is the AGC attenuator. Y032 feeds the read signal to Y033 which is the second stage amplifier. The output of Y033 is about 4.5 volts, peak to peak, when the AGC is enabled. Y030, Y031, Y032, and Y033 are contained in the read/write chassis. The output of Y033 is fed to the main logic chassis to Y034. Y034 is a rectifier and level detector. Y034 has two outputs, one output



READ/WRITE/ERASE/HEAD SELECT

is the rectified Read signal (pin 5 and 6), the other output is an enable (pin 12) to the following stage (Y035). The enable is present when the Read signal into Y034 exceeds the clipping level (established at 2 volts by R103, R104, and CR100). Level detection is used to clip low level noise which otherwise could be detected as data.

Y035 is a peak detector which generates a 0.75 usec pulse at the point of slope reversal of the Read Data signal. The output of Y035 is standard logic level. Y036 is the AGC rectifier. A portion of the Read signal from Y034 is used by Y036 to charge a capacitor and establish the amount of attenuation required by Y032 to provide 4.5 volts from Y033. Attenuation is increased as the charge on the capacitor is increased. The capacitor is discharged by the AGC Disable signal. A "0" on pin 3 of Y036 will discharge the capacitor and a "1" will allow the capacitor to charge. The capacitor is discharged preceding a read operation to allow a new level to be established for each new block of data.

The data output of Y035 is delayed 350 nsec, shaped to 550 nsec, and transmitted to the controller by T002. The data output of Y035 is also used to drive the phase A resync circuits.

I033 clears the Resync I FF (K050/051) and the Resync II FF (K060/061), and toggles K030/031. I036 transfers K030/031 to K040/041 and allows either Resync I or Resync II FFs to set. If the Resync I FF sets, the read/write oscillator (C000) will start and 700 KC phase A pulses will be transmitted to the controller until the next logical "1" data bit is received. Reciept of the next data "1" bit will again toggle K030/031 and clear the Resync I FF when I033 outputs a "1". When I036 outputs a "1", K030/031 will transfer to K040/041 and the Resync II FF will be set. This will turn on the read oscillator (C001) and again cause 700 KC phase A pulses to be transmitted by T001 to the controller. The phase A pulses are used by the controller during a read operation to synchronize cell time so data zeros can be detected (a data pulse is not transmitted for data zeros).

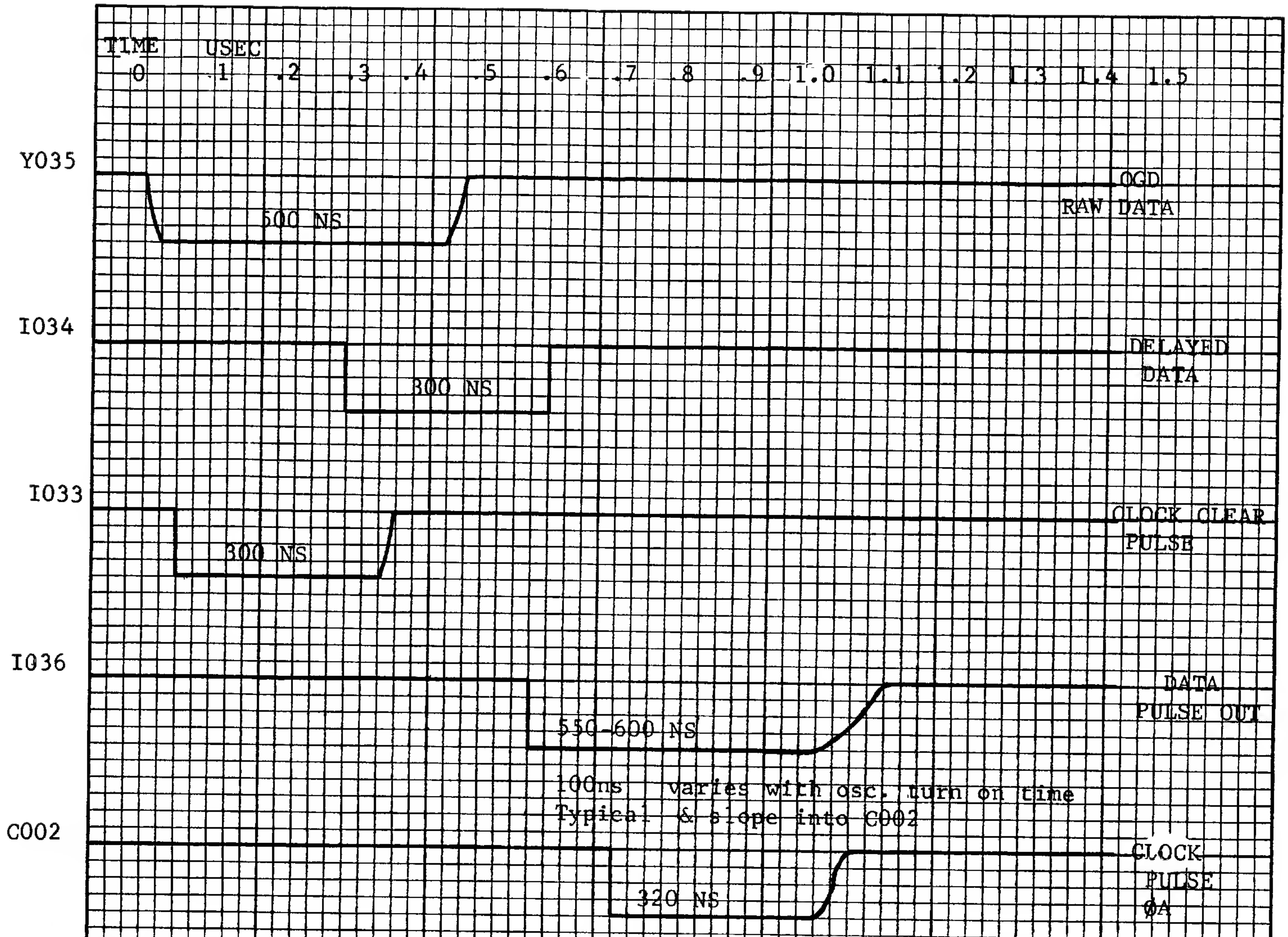
ERROR DETECTION

The Fault FF E000/001 provides a Data Unsafe signal to the controller if one of the following malfunctions occur:

1. more than one head is selected.
2. erase or write driver failure.
3. more than one disk drive unit is selected.

Head Select Error

The AND gate (Y010) senses for two types of errors: Pins 8 and 9 sense write/erase driver fault; Pin 7 senses head select error. The output of Y010 is normally a "0" If the current to pin 7 exceeds 4 ma, the output will switch to a "1". Pin 5 or pin 11 of each IOD (G000-G009) will switch


TIME USEC
0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5
Y035
500 NS
OGD
RAW DATA
I034
300 NS
DELAYED
DATA
I033
300 NS
CLOCK CLEAR
PULSE
I036
550-600 NS
DATA
PULSE OUT
100ns varies with osc. turn on time
Typical & slope into C002
C002
320 NS
CLOCK
PULSE
ØA

READ TIMING

from 0 ma to 4 ma when selected. If more than one IOD is selected, greater than 4 ma will be delivered to pin 7 of the AND gate (Y010) and the output of Y010 will switch to a "1", setting the Fault FF E000/001.

Erase/Write Driver Failure

Pins 8 and 9 of Y010 form a bridge circuit with four head driver transistors. G020 write driver and G022 erase driver provide one leg of the bridge. G021 write driver and G023 dummy driver provide the other leg of the bridge. If any one of the transistors becomes open or shorted, the bridge will become unbalanced and cause the output of Y010 to switch from a "0" to a "1".

Unit Select Error

I001 will output a "1" when the unit is selected. This will be unit 0 when wired as shown in the diagrams. I006 will output a "1" when any other unit is selected. If both conditions occur at the same time, the pin 3 AND gate into E000/001 will set the Fault FF.

MANUAL OPERATIONS

Manual operations are enabled when the on-line/off-line key switch is in the off-line position. R/W head zero is selected for all off-line functions. I900 breaks the AND gate into I003 to enable G000 and select head zero. External jumpers must be used to select the other 9 heads. Three manual functions are provided by the manual function switch:

1. read.
2. erase.
3. erase/write.

I902 will output a "1" when the function switch is in the read position. This "1" into I030 will fake the Signal Gate and turn on the preamp Y031. The "1" into I037 will fake the Read Gate signal and enable the phase A oscillator circuits. With the read circuits fully enabled, circuit analysis can be made to locate a fault.

I903 will output a "1" when the function switch is in the erase position. This will fake the Write Gate signal with a "1" into I020 and turn on the erase driver G022.

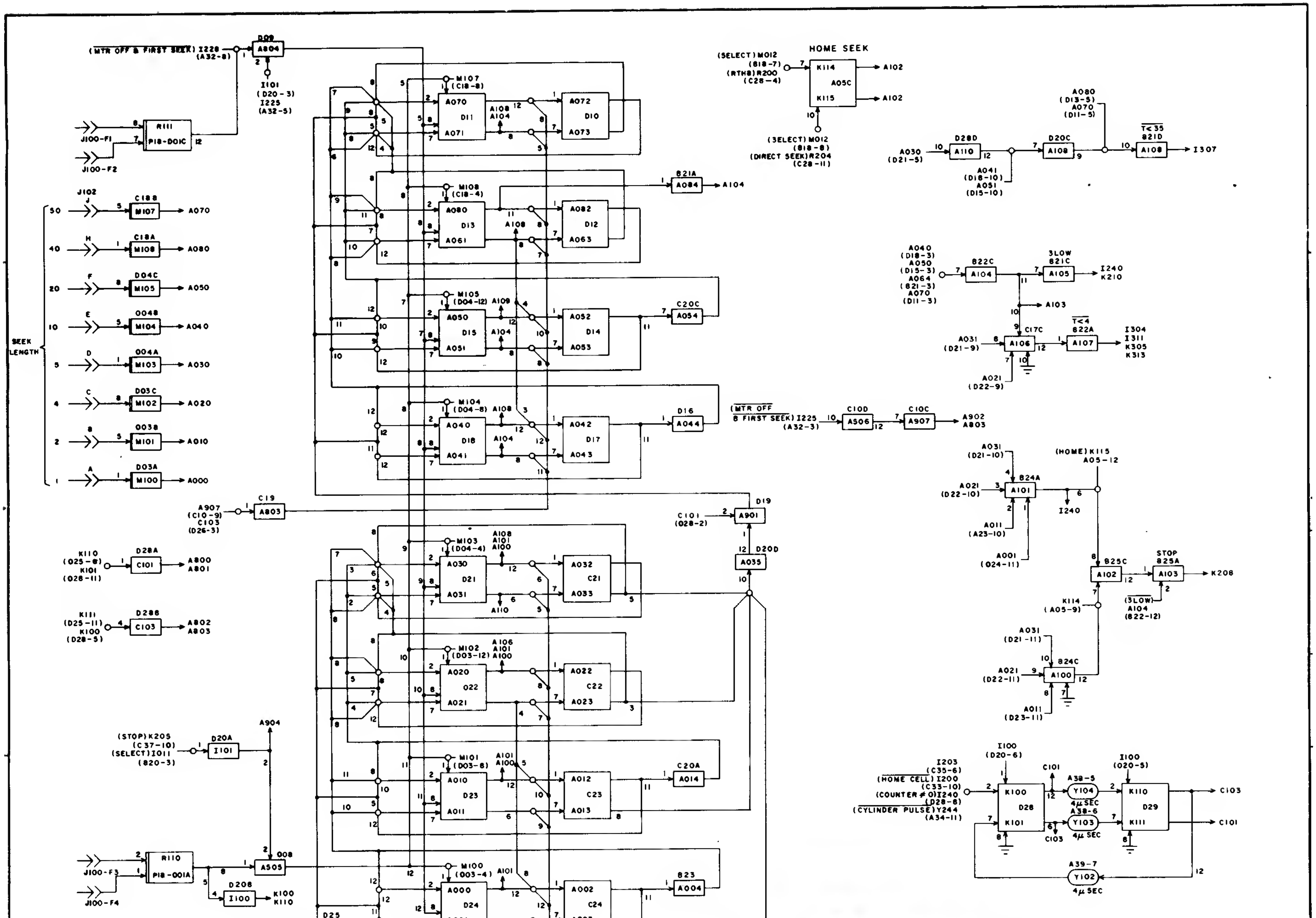
I901 will output a "1" when the function switch is in the write position. This will fake the Write Gate signal with a "1" into I020, which will turn on the erase driver. The "0" from I020 will also turn on the write oscillator by breaking the AND gate into C000. C002 and I109 are ANDed into I022 to fake the Data pulses into M099. M099 is enabled with a "0" on pin 3. M099 will toggle at a 700 KC rate and write continuous data one bits.

SECTION III

852 DIAGRAMS, FLOW CHARTS, AND TIMING CHARTS

CHAPTER I

852 DIAGRAMS



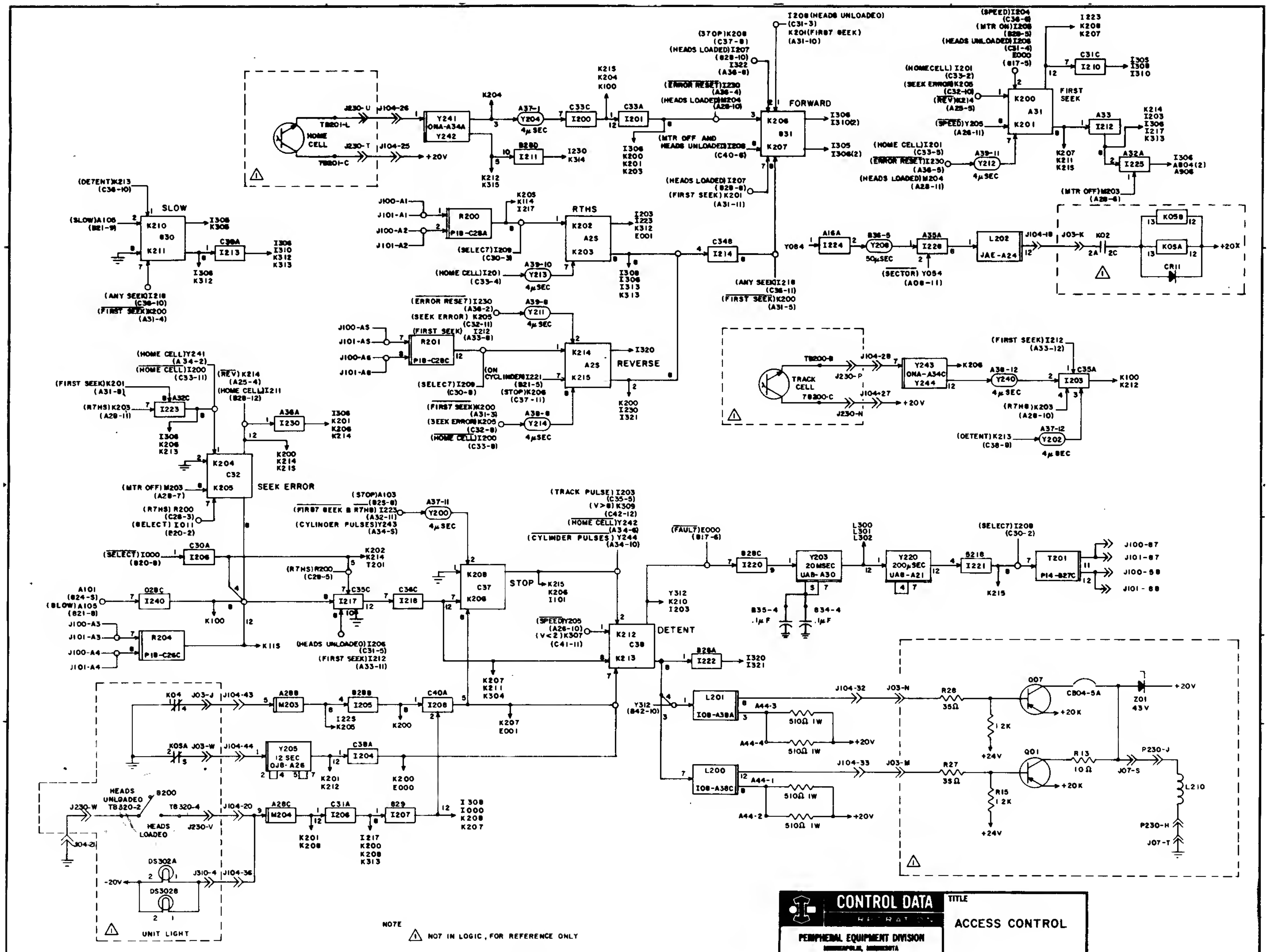
CONTROL DATA CORPORATION

PERIPHERAL EQUIPMENT DIVISION

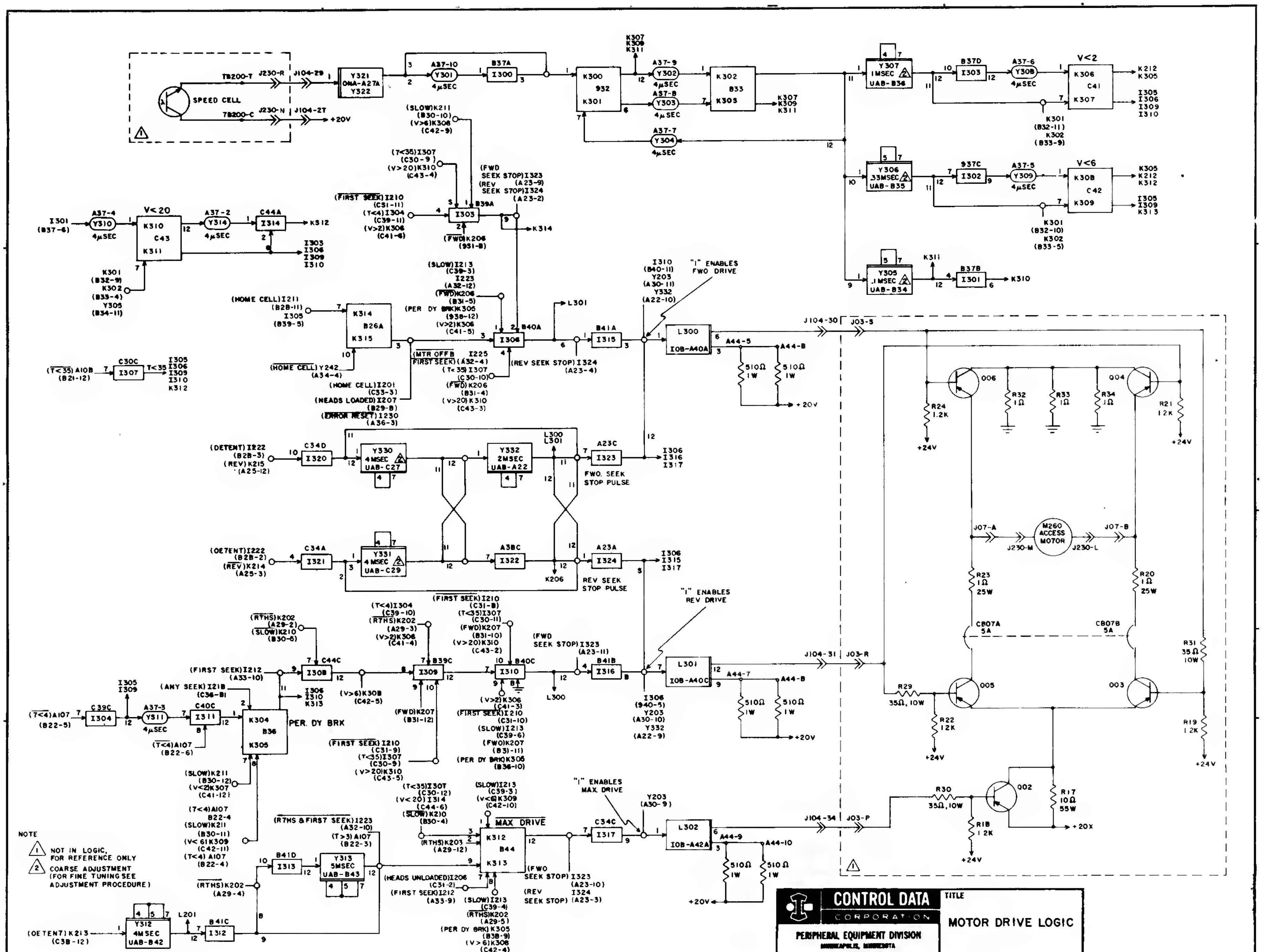
MINNEAPOLIS, MINNESOTA

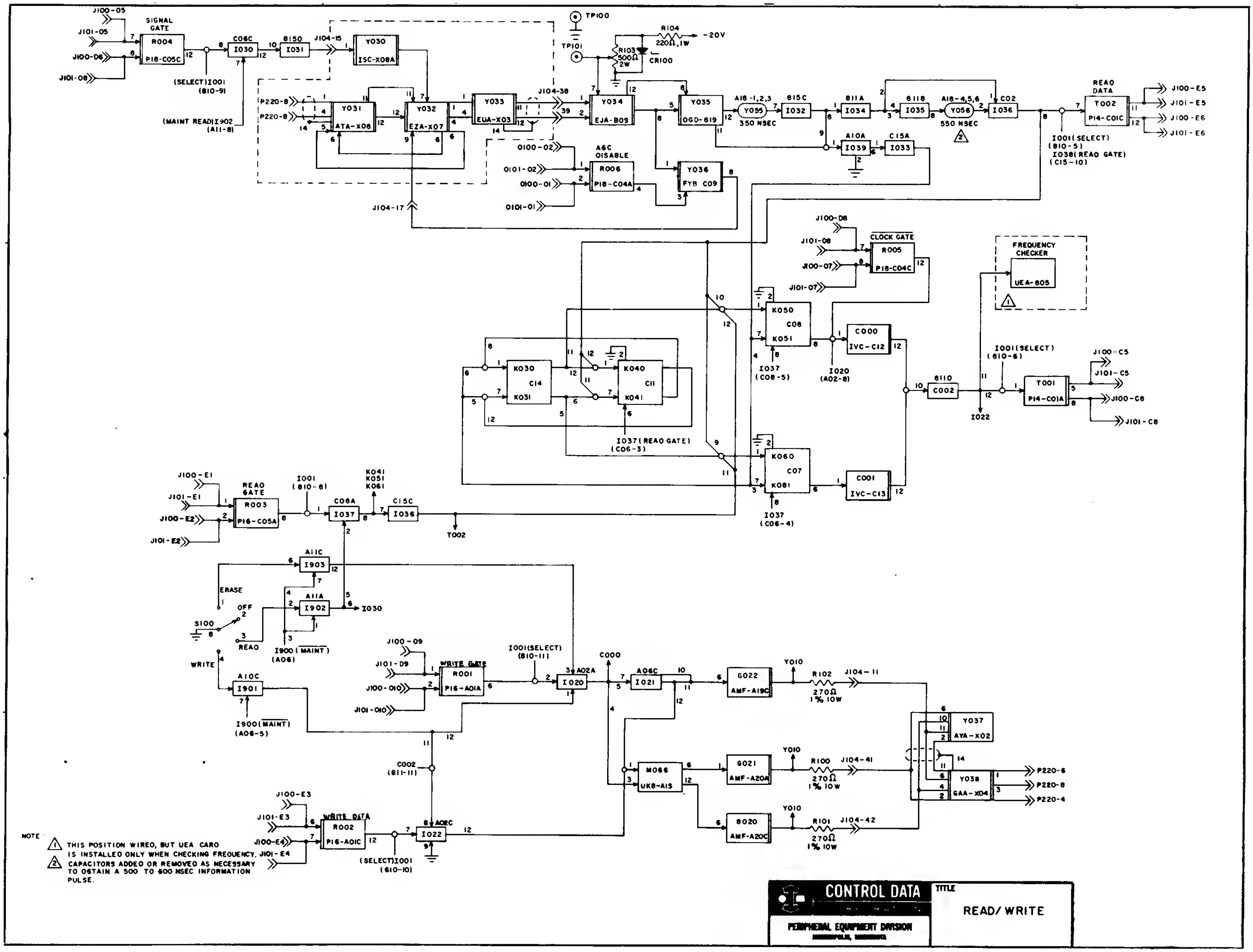
TITLE

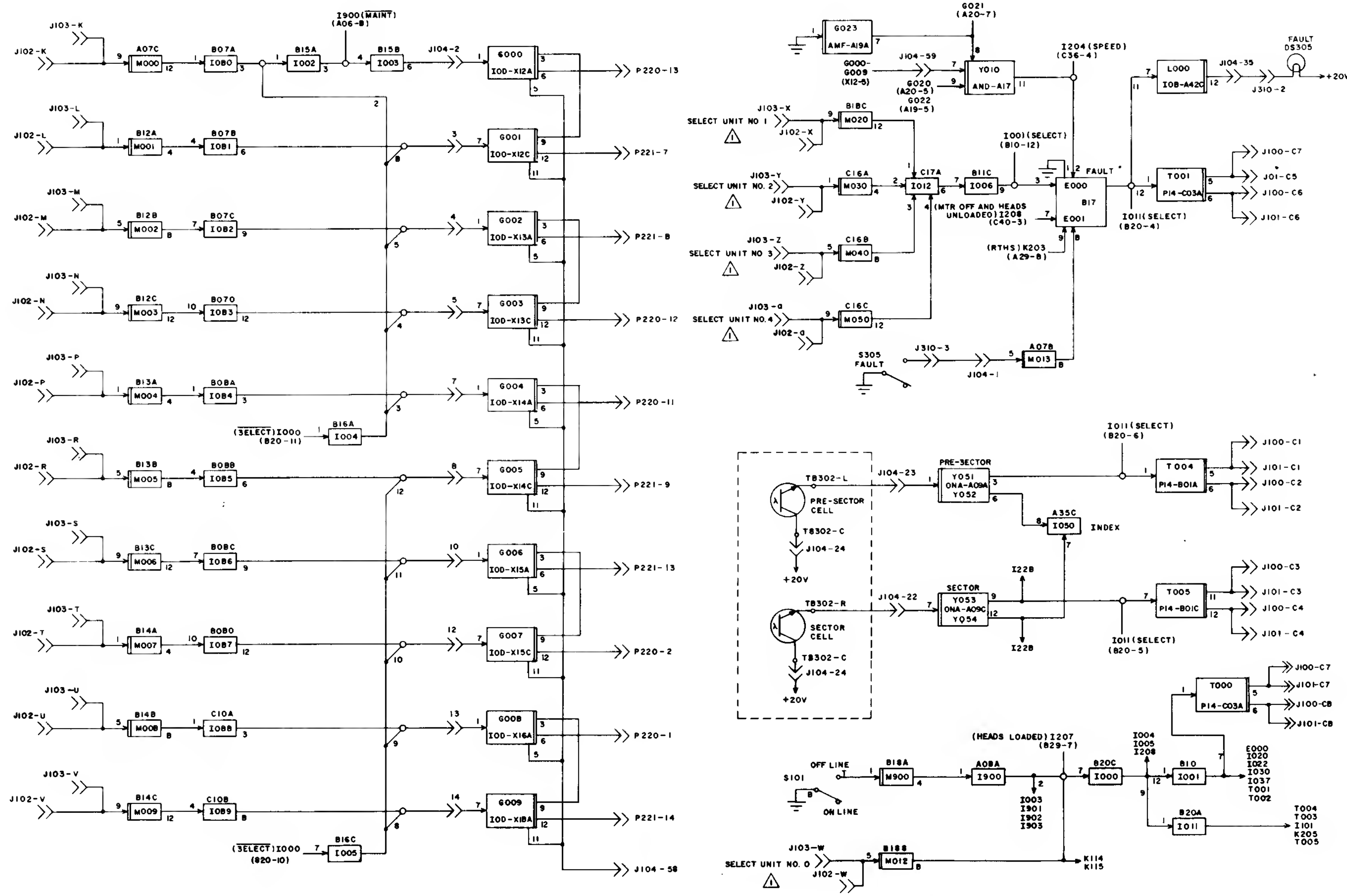
POSITION LOGIC



SLOW
RTHS
FORWARD
FIRST SEEK
REVERSE
SEEK ERROR
STOP
DETENT
HOME CELL
TRACK CELL
HEADS UNLOADED
HEADS LOADED
UNIT LIGHT
NOTE
NOT IN LOGIC, FOR REFERENCE ONLY
CONTROL DATA
PERIPHERAL EQUIPMENT DIVISION
TITLE
ACCESS CONTROL


SPEED CELL
M260 ACCESS MOTOR
"1" ENABLES FWD DRIVE
"1" ENABLES REV DRIVE
"1" ENABLES MAX DRIVE
FWD. SEEK STOP PULSE
REV SEEK STOP PULSE
MAX DRIVE
PER. DY BRK
NOTE
1 NOT IN LOGIC, FOR REFERENCE ONLY
2 COARSE ADJUSTMENT (FOR FINE TUNING SEE ADJUSTMENT PROCEDURE)
CONTROL DATA CORPORATION
PERIPHERAL EQUIPMENT DIVISION
MINNEAPOLIS, MINNESOTA
TITLE
MOTOR DRIVE LOGIC


SIGNAL GATE
R004
P18-C05C
J100-05
J101-05
J100-06
J101-06
(SELECT)I001
(810-9)
(MAINT READ)I902
(A11-8)
C06C
I030
8150
I031
J104-15
Y030
ISC-X08A
P220-8
P220-6
Y031
ATA-X06
Y032
EZA-X07
Y033
EUA-X03
J104-17
TP100
TP101
R104
220Ω, 1W
-20V
R103
500Ω
2W
CR100
J104-38
Y034
EJA-B09
Y035
OGD-619
A16-1,2,3
Y055
350 NSEC
815C
I032
811A
I034
611B
I035
A16-4,5,6
Y056
550 NSEC
C02
I036
READ DATA
T002
P14-C01C
J100-E5
J101-E5
J100-E6
J101-E6
I001(SELECT)
(810-5)
I038(READ GATE)
(C15-10)
A10A
I039
C15A
I033
A6C
DISABLE
R006
P18-C04A
0100-02
0101-02
0100-01
0101-01
Y036
FYB C09
J100-06
J101-06
J100-07
J101-07
CLOCK GATE
R005
P18-C04C
FREQUENCY CHECKER
UEA-605
K050
C06
K051
I037
(C08-5)
C000
IVC-C12
I020
(A02-8)
K030
C14
K031
K040
C11
K041
I037(READ GATE)
(C06-3)
6110
C002
I001(SELECT)
(610-6)
I022
T001
P14-C01A
J100-C5
J101-C5
J100-C6
J101-C6
K060
C07
K061
C001
IVC-C13
I037
(C06-4)
J100-E1
J101-E1
J100-E2
J101-E2
READ GATE
R003
P16-C05A
I001
(610-6)
C06A
I037
K041
K051
K061
C15C
I036
T002
A11C
I903
ERASE
OFF
S100
READ
WRITE
A11A
I902
I030
I900(MAINT)
(A06)
A10C
I901
I900(MAINT)
(A06-5)
J100-09
J101-09
J100-010
J101-010
WRITE GATE
R001
P16-A01A
I001(SELECT)
(610-11)
A02A
I020
C000
A06C
I021
G022
AMF-A19C
Y010
R102
270Ω
1% 10W
J104-11
M066
UK8-A15
G021
AMF-A20A
R100
J104-41
8020
AMF-A20C
R101
J104-42
Y037
AYA-X02
Y038
GAA-X04
P220-6
P220-8
P220-4
C002
(611-11)
J100-E3
J101-E3
J100-E4
J101-E4
WRITE DATA
R002
P16-A01C
A02C
I022
(SELECT)I001
(610-10)
NOTE
1 THIS POSITION WIRED, BUT UEA CARD IS INSTALLED ONLY WHEN CHECKING FREQUENCY.
2 CAPACITORS ADDED OR REMOVED AS NECESSARY TO OBTAIN A 500 TO 600 NSEC INFORMATION PULSE.
CONTROL DATA
PERIPHERAL EQUIPMENT DIVISION
TITLE
READ/WRITE



2-3-4-6-8

NOTE: ⚠ SHOWN AS WIRED IN PRODUCTION

CONTROL DATA

PERIPHERAL EQUIPMENT DIVISION

MINNEAPOLIS, MINNESOTA

TITLE

HEAD SELECT

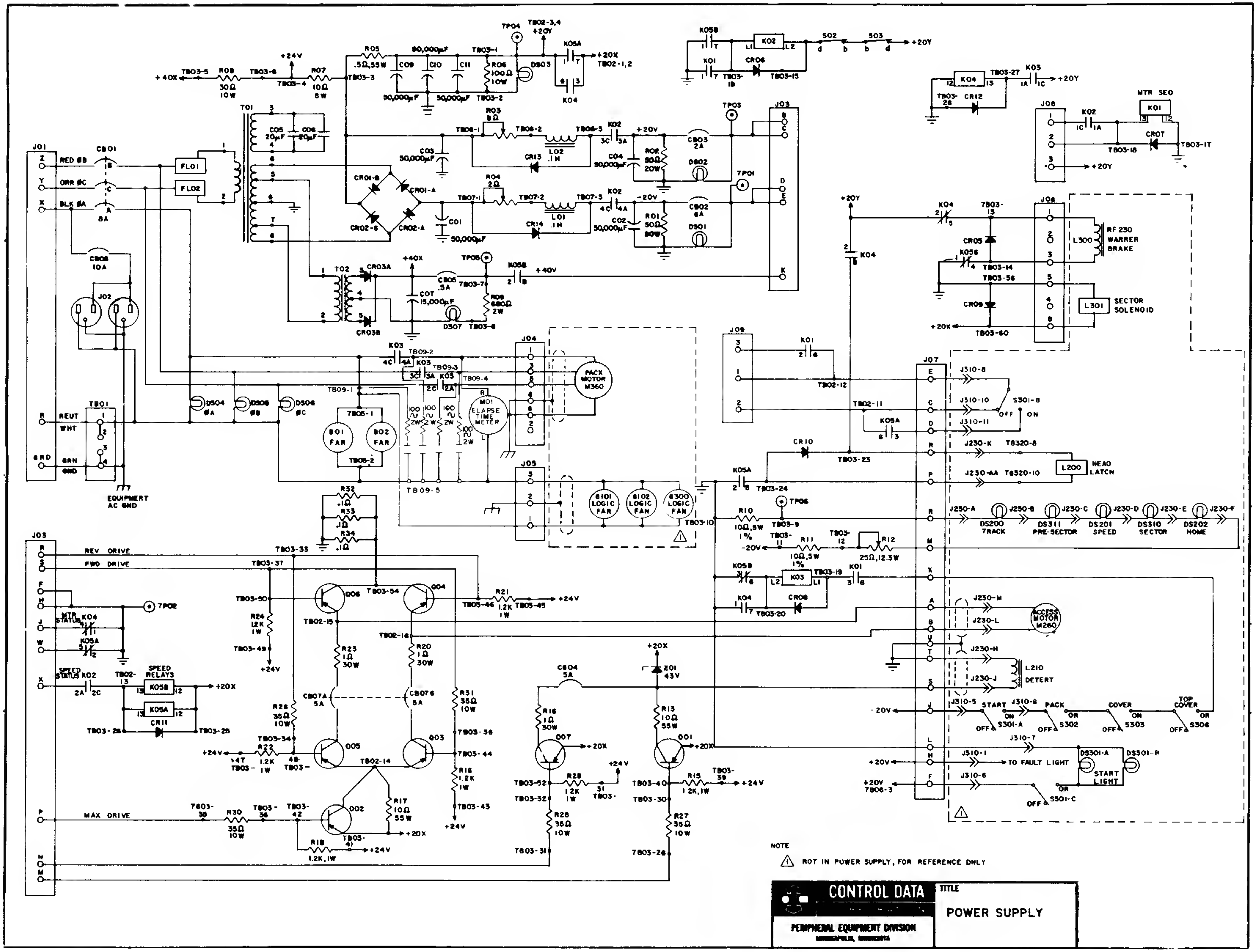
Column	A	B	C	D
1	R001, R002 (P18)	T004, T005 (P14)	T001, T002 (P14)	R110, R111 (P18)
2	I020, I022 (23)		I036 (12)	
3			T000, T003 (P14)	M100, M101, M102 (87)
4			R006, R005 (P18)	M103, M104, M105 (87)
5	K020, K021, K114, K113 (30)	(UEA)	R003, R004 (P18)	
6	I900, I021 (21)		I037, I030 (22)	
7	M013, M000 (87)	I080, I081, I082, I083 (20)	K060, K061 (32)	
8		I064, I085, I086, I087 (20)	K050, K051 (32)	A905 (12)
9	Y031, Y032, Y053, Y034 (ONA)	Y034 (EJA)	Y036 (FYB)	A904 (12)
10	I039, I901 (22)	I001 (11)	I088, I089, A907, A908 (20)	A072, A073 (31)
11	I902, I903 (22)	I034, I035, I006, C002 (20)	K040, K041 (32)	A070, A071 (32)
12		M001, M002, M003 (87)	C000 (IVC)	A062, A063 (31)
13		M004, M005, M006 (87)	C001 (IVC)	A060, A061 (32)
14		M007, M008, M009 (87)	K030, K031 (31)	A052, A053 (31)
15	M099 (UKB)	I002, I003, I032, I031 (20)	I033, I038 (21)	A050, A051 (32)
16	I224 (20)	I004, I005 (21)	M030, M040, M050 (87)	A044 (11)
17	Y010 (AND)	E000, E001 (33)	I012, A106 (24)	A042, A043 (31)
18	Y055, Y055, Y055, Y056, Y056, Y056, Y056 (EEE)	M900, M012, M020 (67)	M106, M107 (87)	A040, A041 (32)
19	G023, G022 (AMF)	Y035 (OGD)	A903 (11)	A901 (12)
20	G021, G020 (AMF)	I011, I000 (21)	A014, A054 (21)	I101, I100, A109, A035 (20)
21	Y220 (UAB)	A064, I221, A103, A108 (20)	A032, A033 (31)	A030, A031 (32)
22	Y332 (UAB)	A107, A104 (21)	A022, A023 (31)	A020, A021 (32)
23	I323, I324 (21)	B004 (11)	A012, A015 (31)	A010, A011 (32)
24	L202 (JAE)	A101, A100 (24)	A002, A003 (31)	A000, A001 (32)
25	K214, K215 (32)	A103, A102 (22)	A902 (11)	A900 (11)
26	Y205 (OJB)	K314, K313 (30)	R204 (P16)	C101, C103, I240, A110 (20)
27	Y321, Y322 (ONA)	T201 (P14)	Y330 (UA6)	
28	M203, M204 (67)	I222, I203, I220, I211 (20)	R200, R201 (P18)	K100, K101 (32)
29	K202, K203 (31)	I207 (11)	Y331 (UA6)	K110, K111 (32)
30	Y203 (UA8)	K210, K211 (32)	I209, I307 (21)	
31	K200, K201 (32)	K206, K207 (33)	I206, I210 (21)	
32	I225, I223 (22)	K300, K301 (31)	K204, K205 (32)	
33	I212 (11)	K302, K303 (31)	I201, I200 (21)	
34	Y241, Y242, Y243, Y244 (ONA)	Y305 (UA8)	I321, I214, I317, I320 (20)	
35	I226, I050 (22)	Y306 (UA8)	I203, I217 (24)	
36	I230, I322 (21)	Y307 (UA8)	I204, I218 (21)	
37	Y204, Y314, Y311, Y310, Y309, Y308, Y304, Y303, Y302, Y301, Y200, Y202 (CC82-1)	I300, I301, I302, I303 (20)	K208, K209 (32)	
38	L201, L200 (IO8)	K304, K305 (32)	K212, K213 (32)	
39	Y104, Y103, Y102, Y214, Y211, Y213, Y212, Y240 (CC82-1)	I305, I309 (24)	I213, I304 (21)	
40	L300, L301 (IO8)	I306, I310 (24)	I208, I311 (22)	
41	DC FILTER (P54)	I315, I318, I312, I313 (20)	K306, K307 (31)	
42	L302, L000 (IO8)	Y312 (UAB)	K308, K309 (31)	
43		Y313 (UA8)	K310, K311 (31)	
44	RESISTOR (EEG)	K312, K313 (33)	I314, I308 (22)	

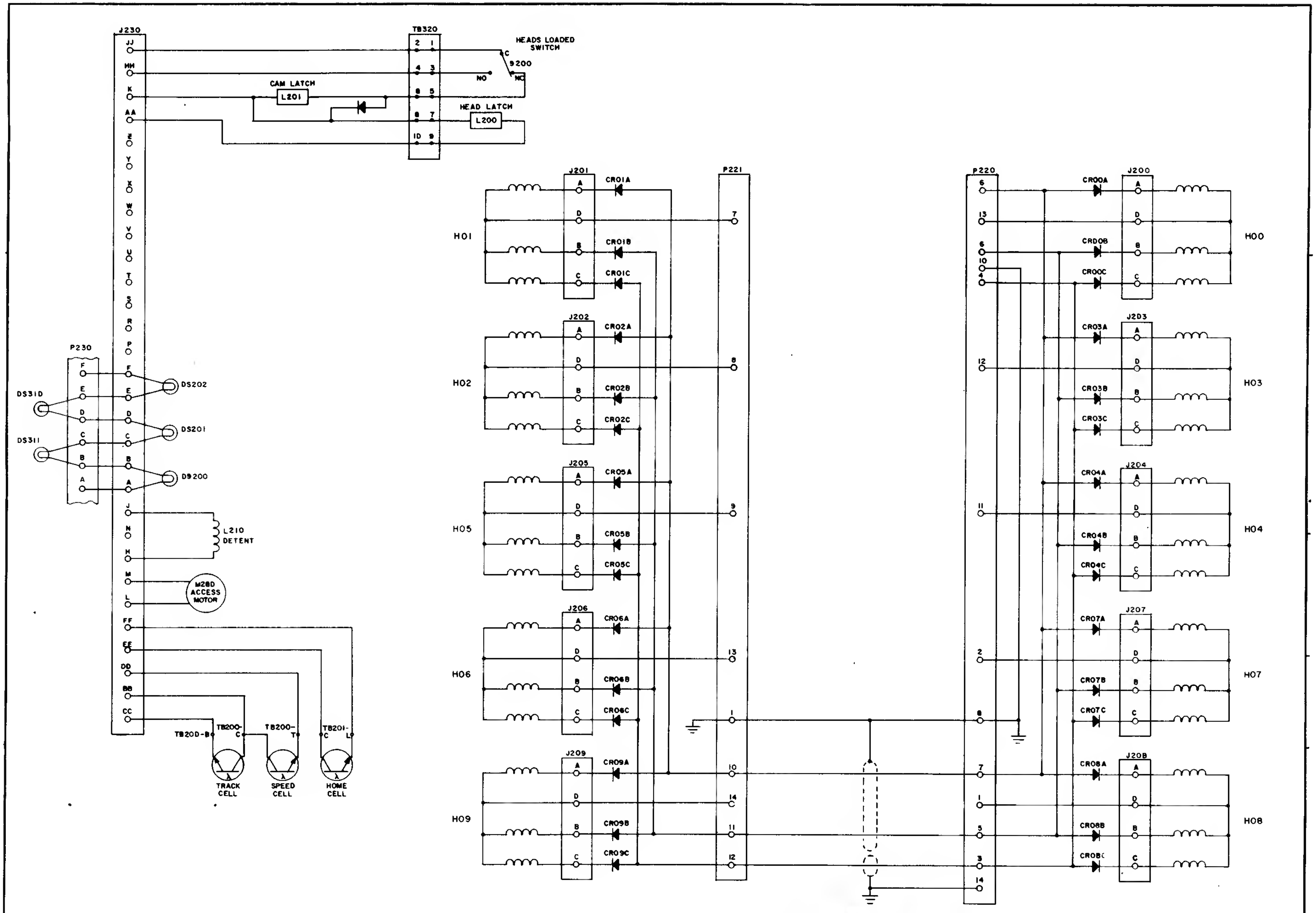
Column	X
1	(+40)
2	Y037 (AYA)
3	Y033 (EUA)
4	Y038 (GAA)
5	(P54)
6	Y031 (ATA)
7	Y032 (EIA)
8	Y030 (I3C)
9–10	±12V SUPPLY CONNECTOR J240
11	
12	G000, G001 (IOD)
13	G002, G003 (IOD)
14	G004, G005 (IOD)
15	G006, G007 (IOD)
16	G008, G009 (IOD)

CONTROL DATA

PERIPHERAL EQUIPMENT DIVISION
MINNEAPOLIS, MINNESOTA

TITLE
CARD PLACEMENT


NOTE
NOT IN POWER SUPPLY, FOR REFERENCE ONLY
CONTROL DATA
PERIPHERAL EQUIPMENT DIVISION
MINNEAPOLIS, MINNESOTA
TITLE
POWER SUPPLY
PACK MOTOR M360
ELAPSE TIME METER
ACCESS MOTOR M260
RF 250 WARNER BRAKE
SECTOR SOLENOID
HEAD LATCH
DETENT
EQUIPMENT AC GND
SPEED RELAYS
REV DRIVE
FWD DRIVE
MAX DRIVE
TO FAULT LIGHT
START LIGHT



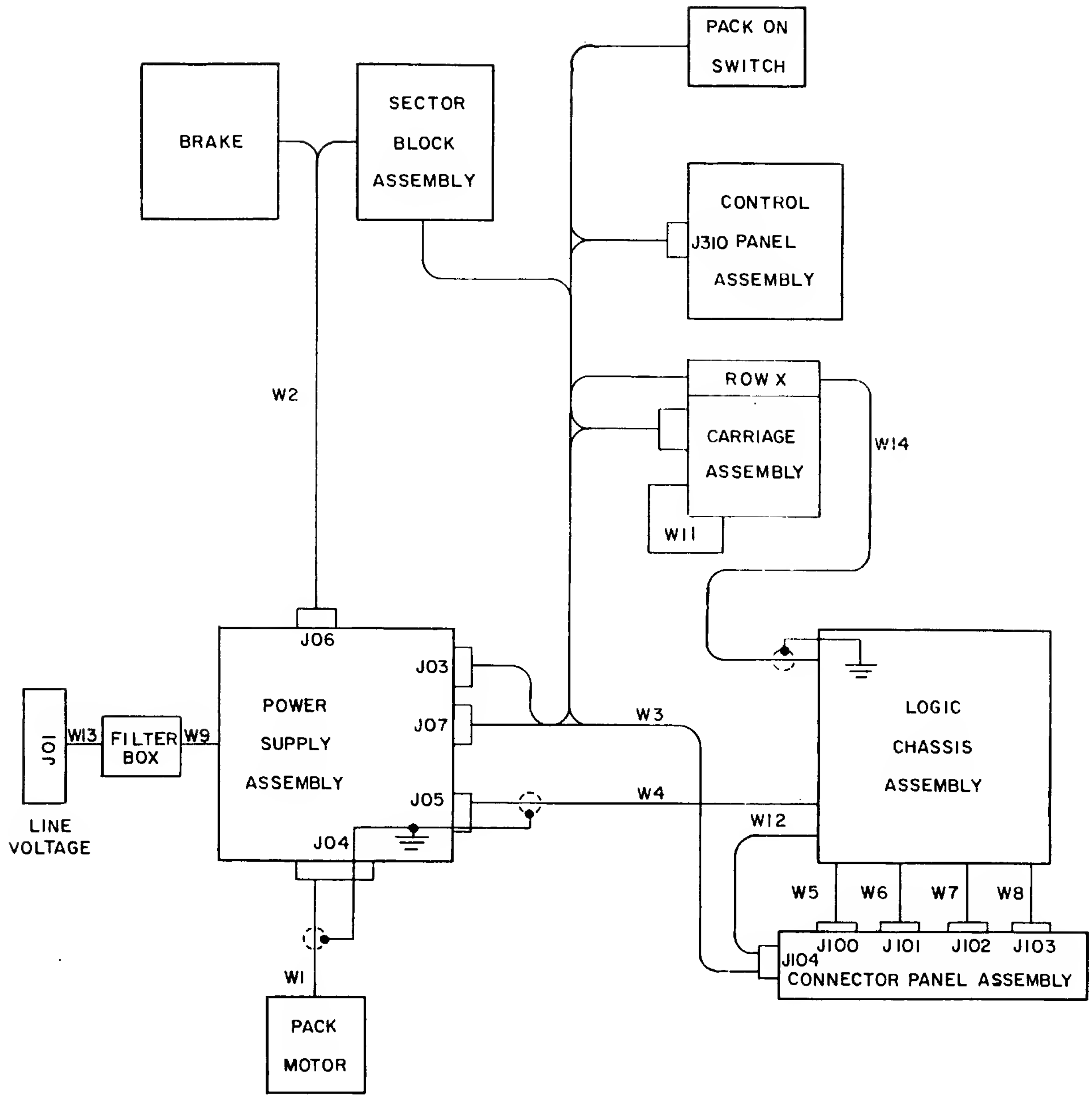
CONTROL DATA CORPORATION

PERIPHERAL EQUIPMENT DIVISION

MINNEAPOLIS, MINNESOTA

TITLE

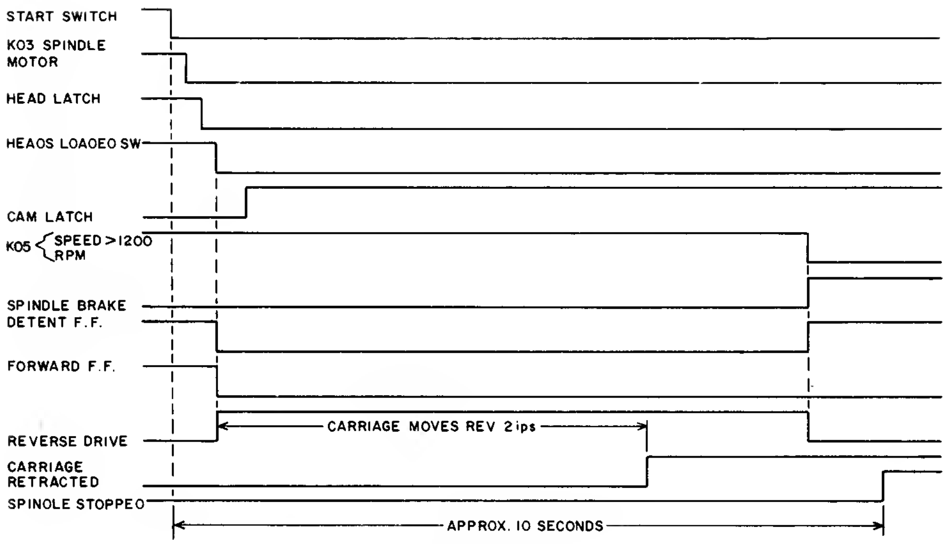
CARRIAGE WIRING



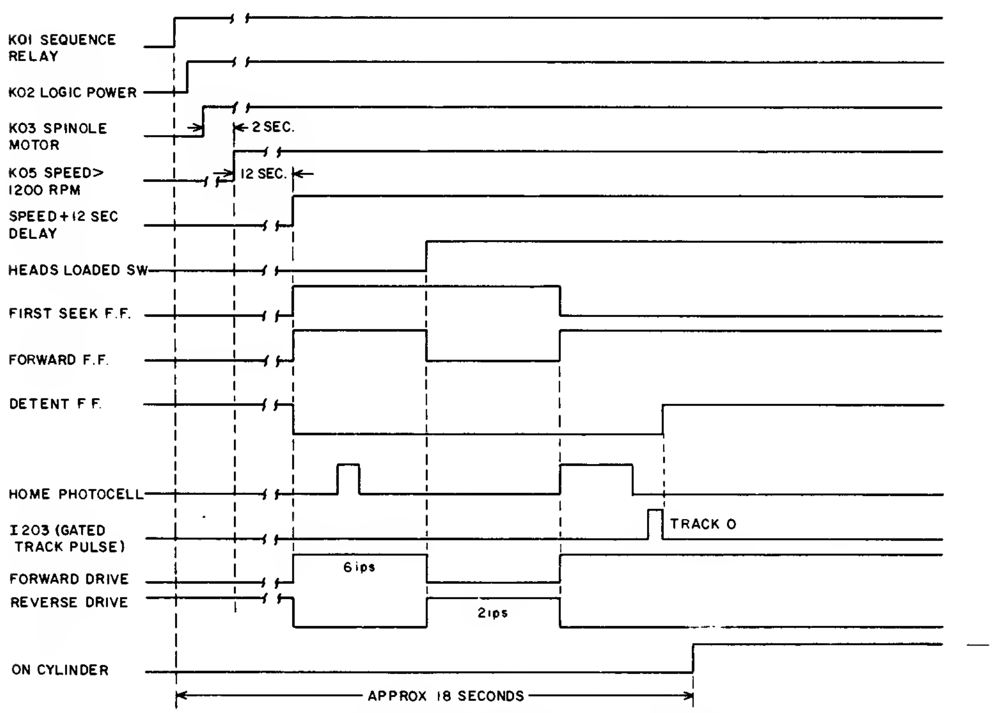
Intercabling of Disk Storage Drive

CHAPTER II

852 FLOW CHARTS AND TIMING CHARTS



POWER OFF SEEK

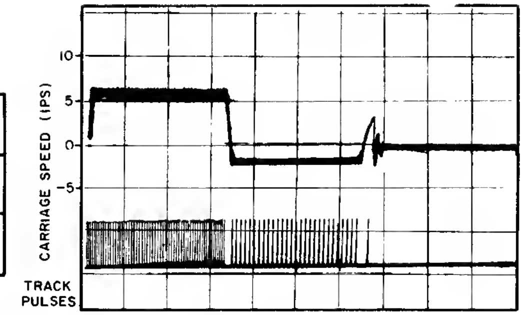


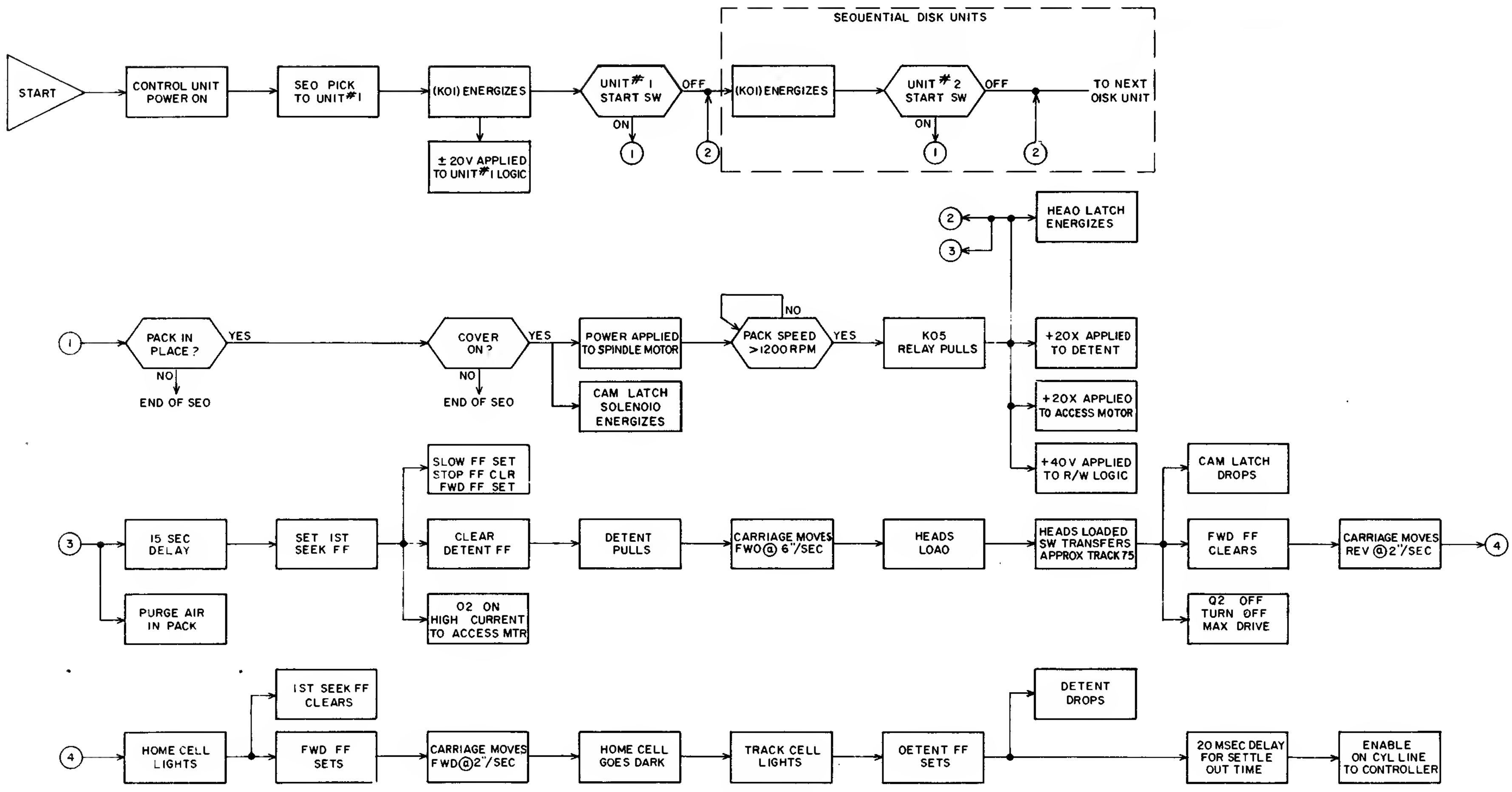
POWER-ON LOAD-HEADS SEEK (FIRST SEEK)

209

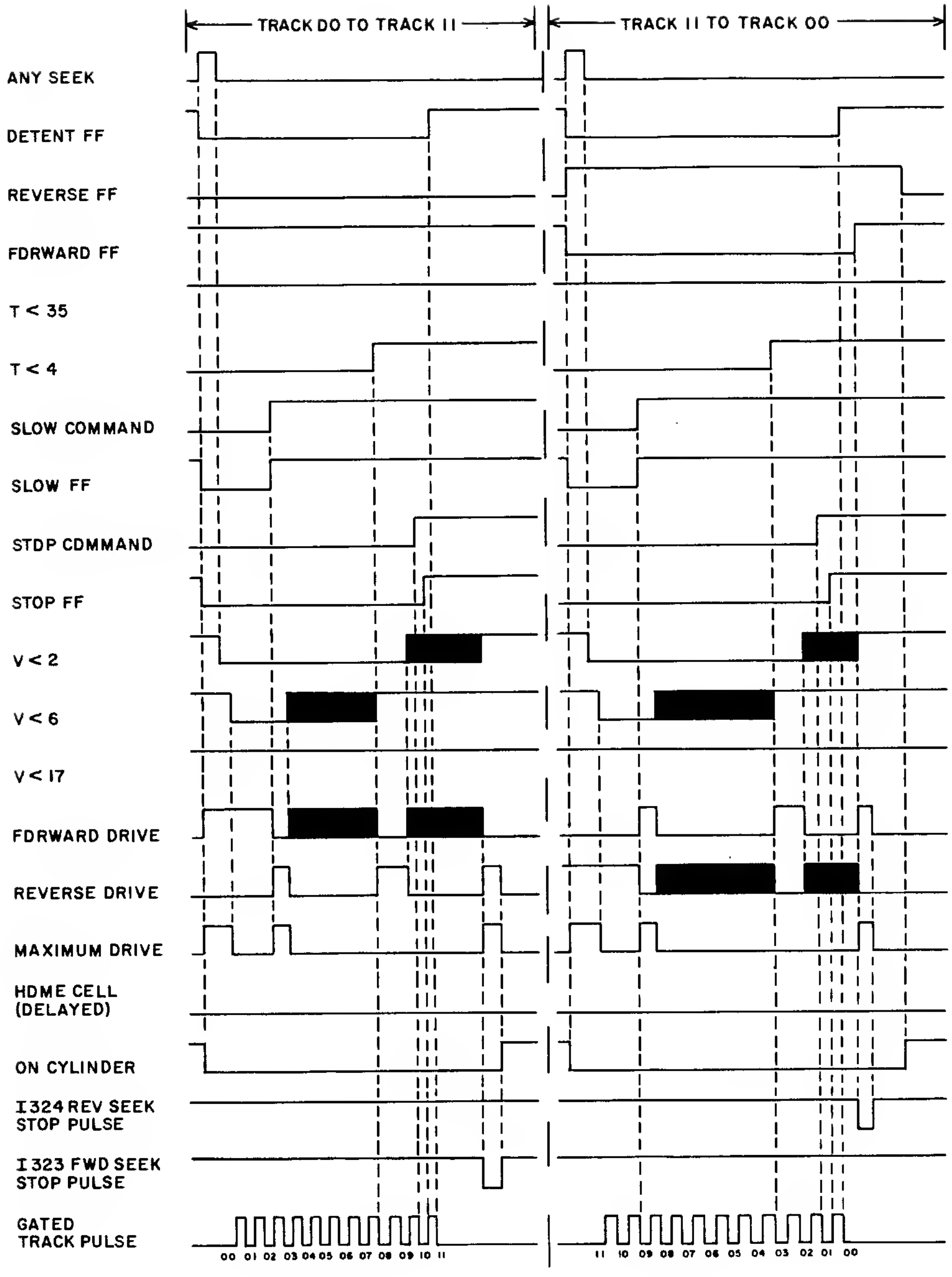
Power On and Power Off Seek Timing

	TOP SWEEP	BOTTOM SWEEP
VERTICAL	2 VOLTS/CM	10 VOLTS/CM
HORIZONTAL	20 MSEC/CM	20 MSEC/CM

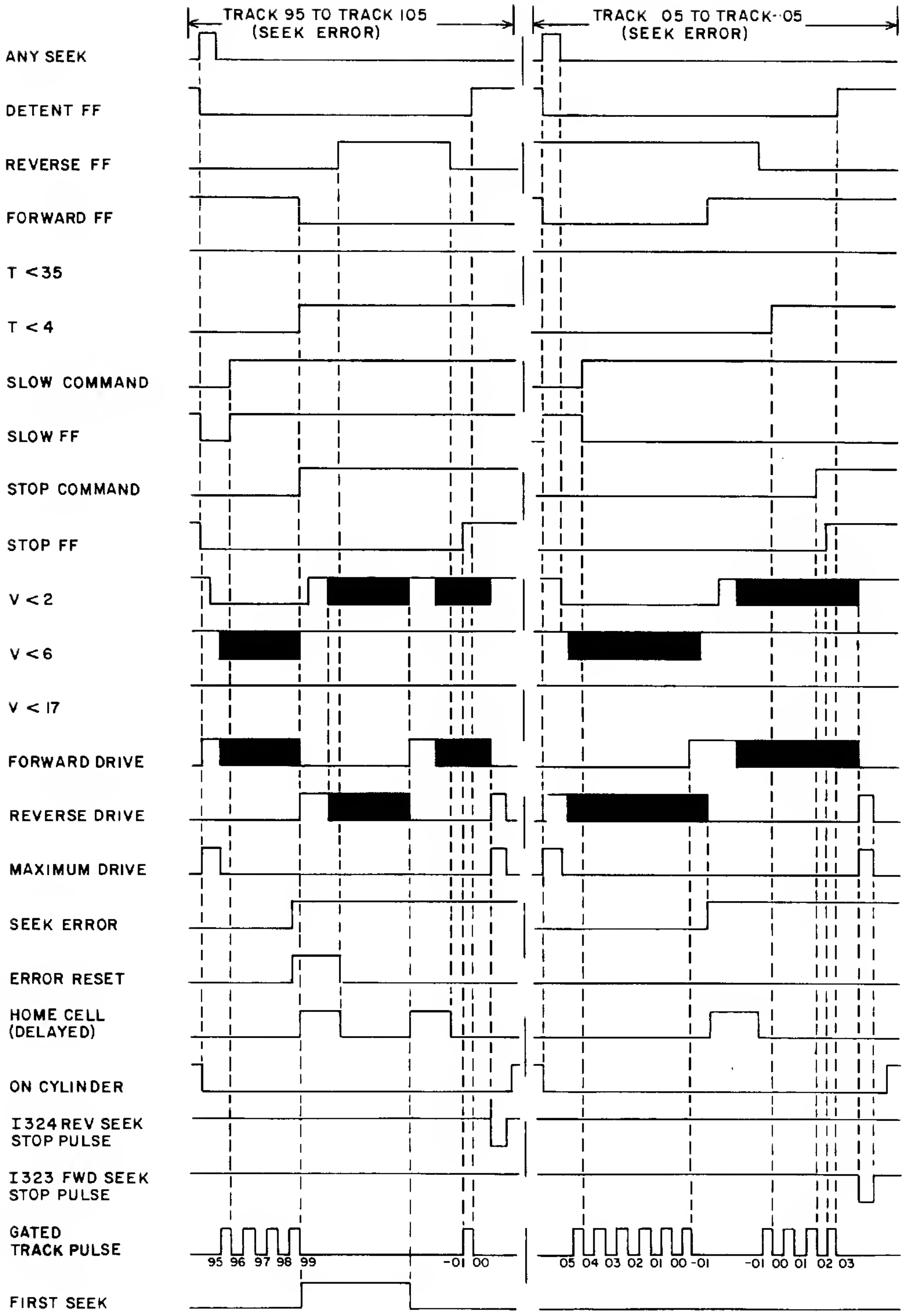




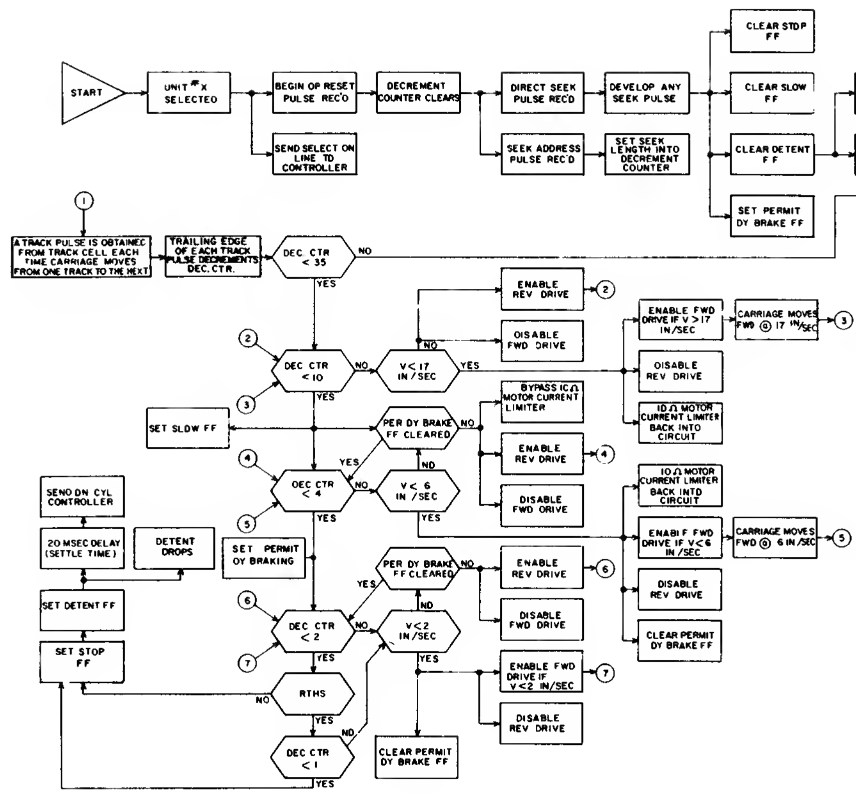
First Seek Operation



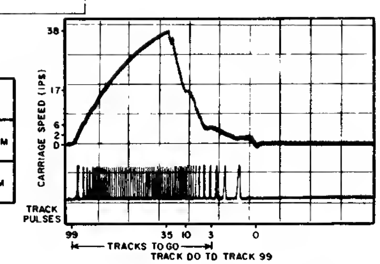
Direct Seek Timing



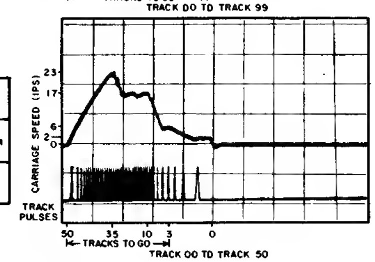
Direct Seek (With Seek Error) Timing



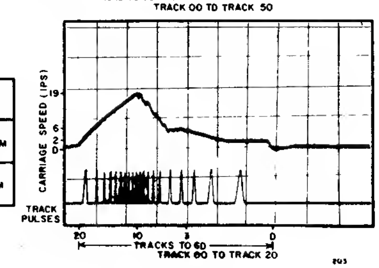
	TOP SWEEP	BOTTOM SWEEP
VERTICAL	2 VOLTS/CM	10 VOLTS/CM
HORIZONTAL	20 MSEC/CM	20 MSEC/CM



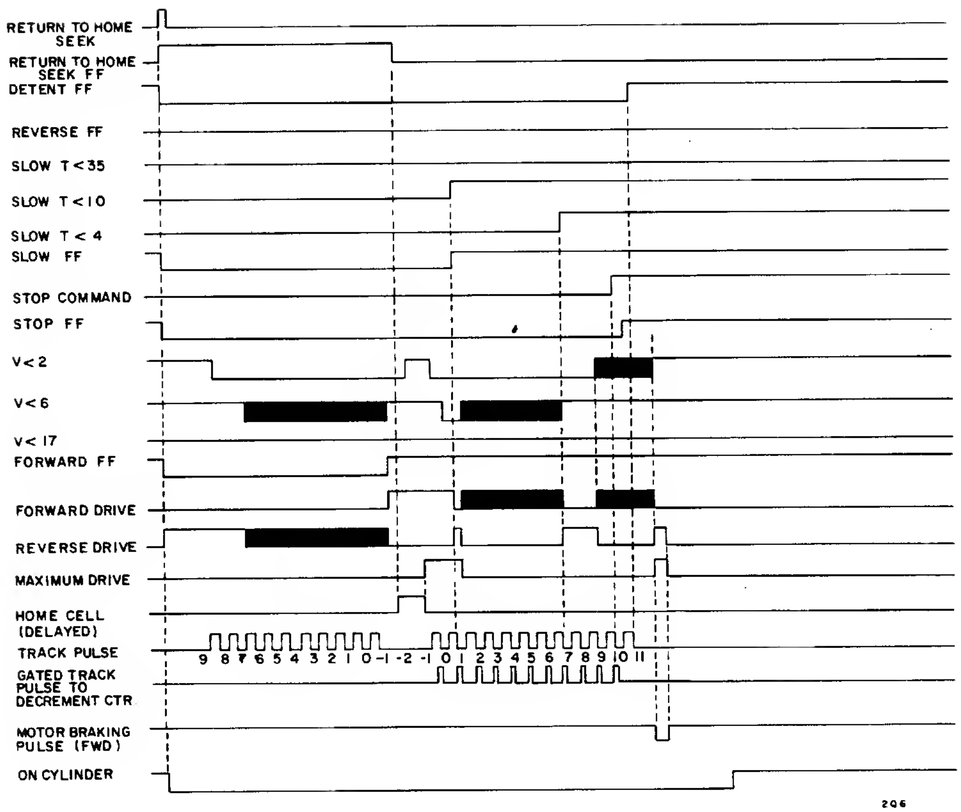
	TOP SWEEP	BOTTOM SWEEP
VERTICAL	2 VOLTS/CM	10 VOLTS/CM
HORIZONTAL	20 MSEC/CM	20 MSEC/CM



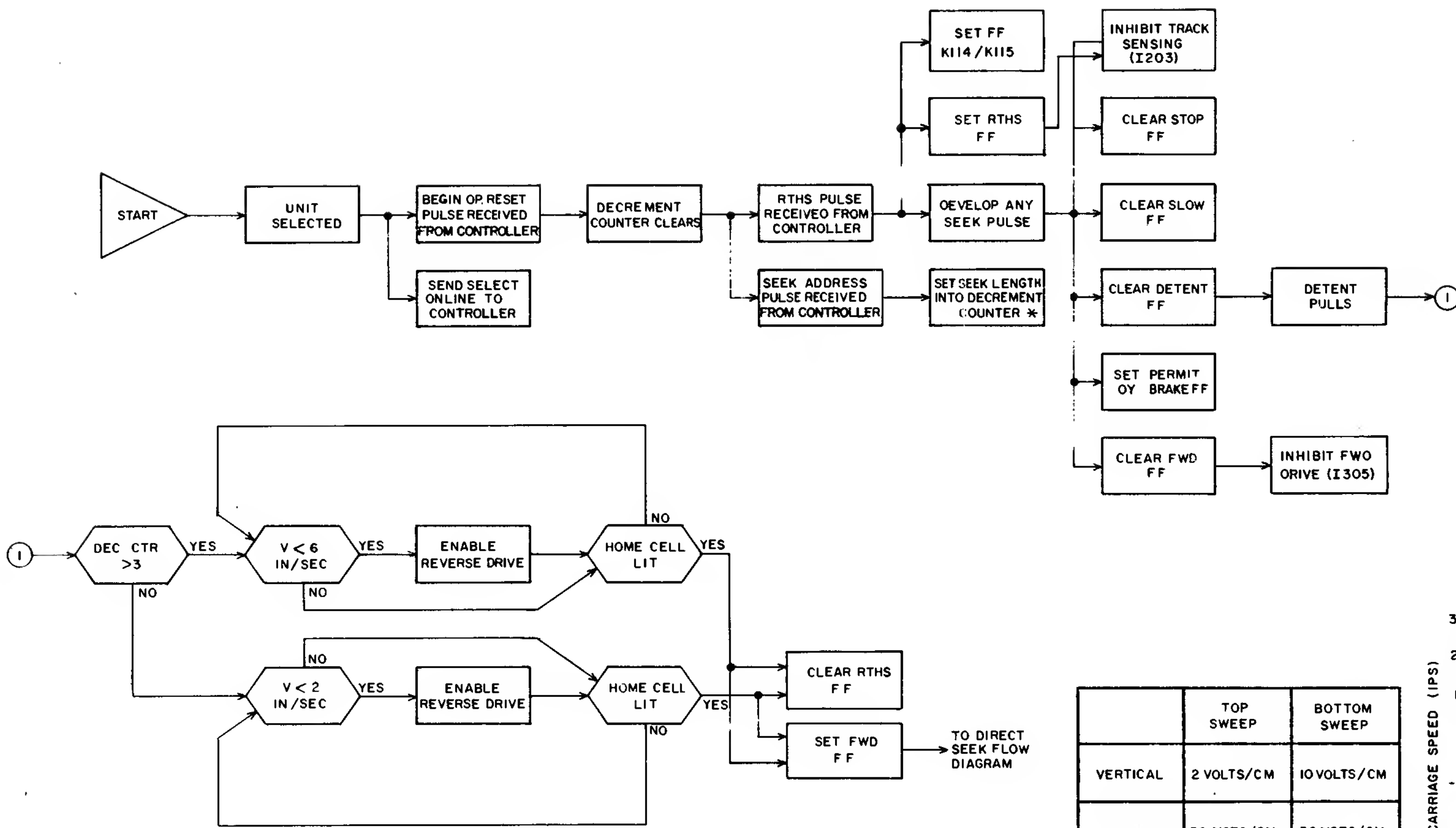
	TOP SWEEP	BOTTOM SWEEP
VERTICAL	2 VOLTS/CM	10 VOLTS/CM
HORIZONTAL	10 MSEC/CM	10 MSEC/CM



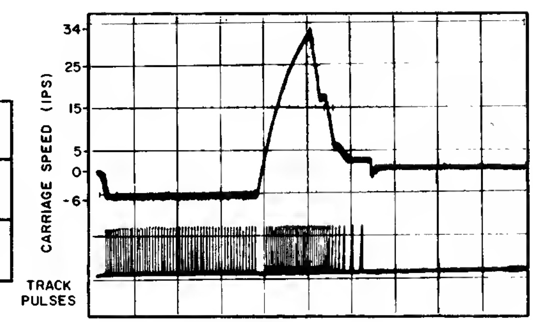
Direct Seek Operation



Return to Home Seek (Track 09 to Track 11) Timing

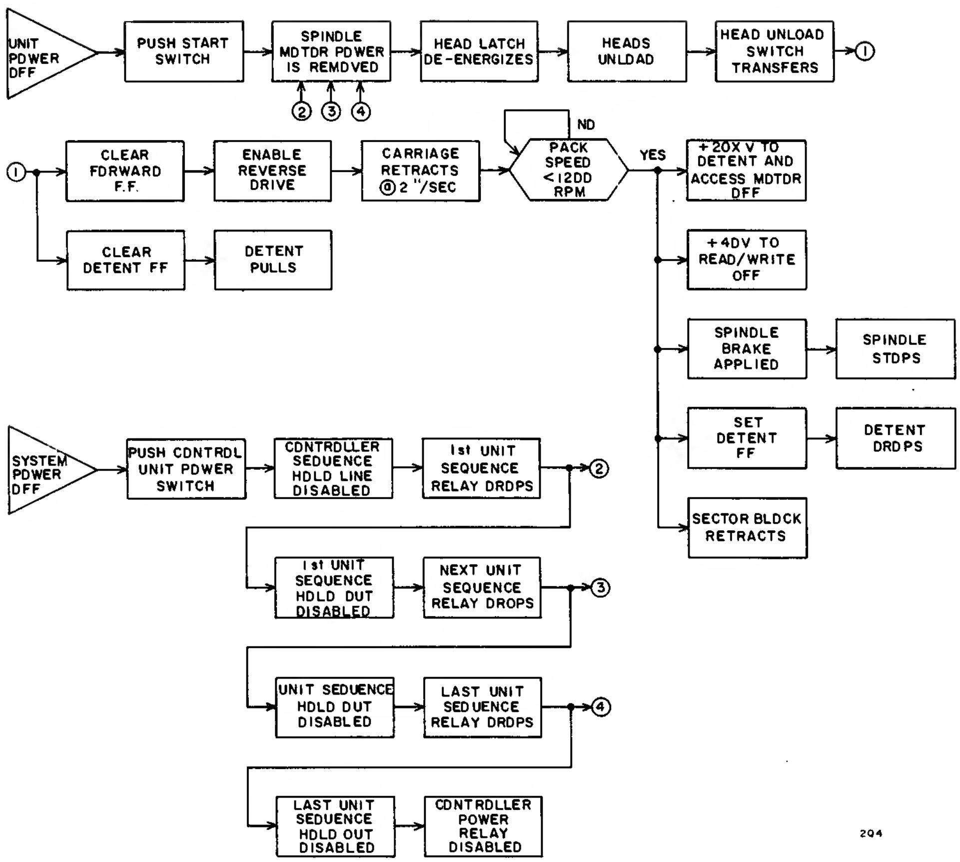


	TOP SWEEP	BOTTOM SWEEP
VERTICAL	2 VOLTS/CM	10 VOLTS/CM
HORIZONTAL	50 MSEC/CM	50 MSEC/CM

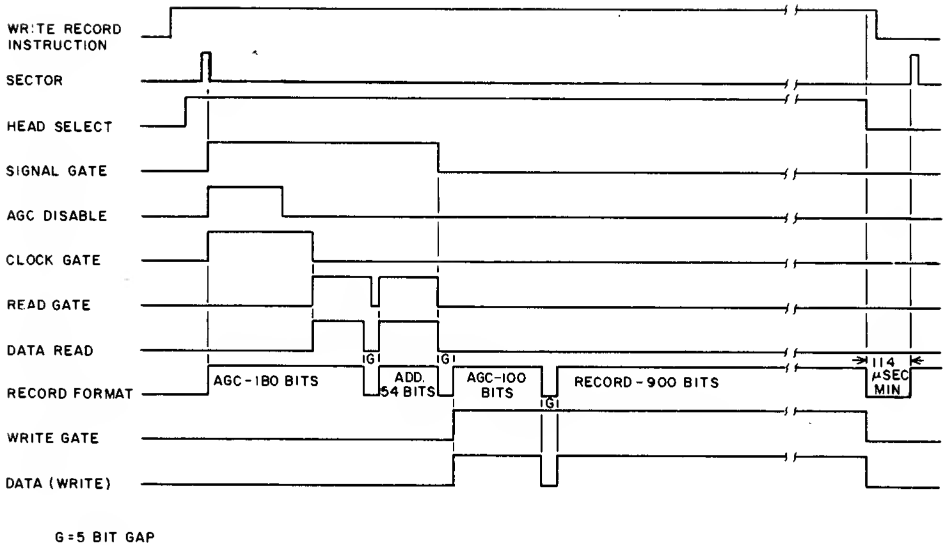


RTHS TRACK 50 TO TRACK 80

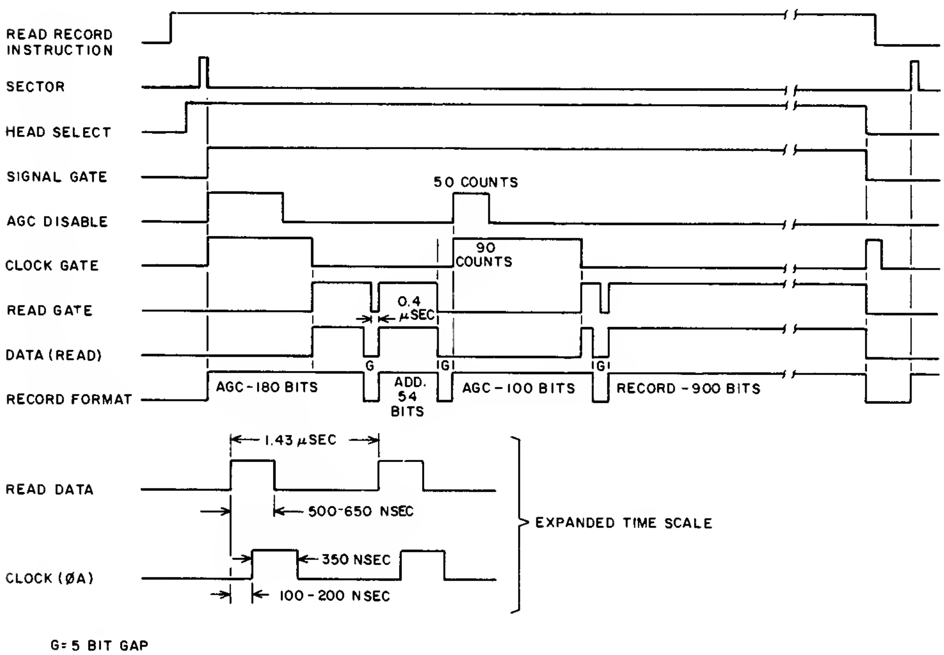
Return to Home Seek Operation



Power Off Seek Operation



DATA & DATA CONTROL TIMING FOR WRITING ONE RECORD



DATA & DATA CONTROL TIMING FOR READING ONE RECORD

205

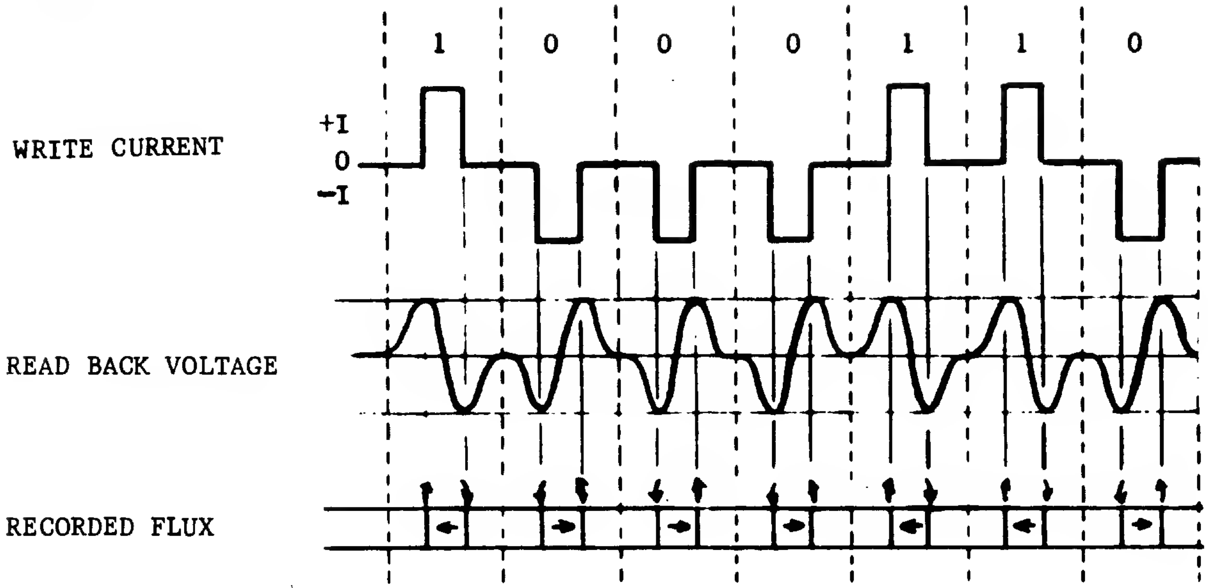
Read and Write Timin

APPENDIX A

DIGITAL MAGNETIC RECORDING TECHNIQUES

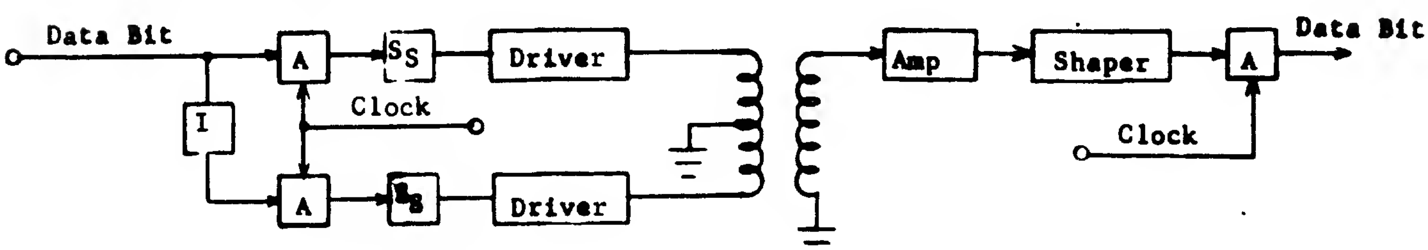
RZ - Return to Zero (Discrete Pulse)

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a positive current pulse and a binary "zero" is recorded by a negative current pulse.

RECORD/PLAY-BACK LOGIC



READ BACK RECOGNITION OF BITS - A binary "one" is recognized by a positive followed by a negative voltage pulse within a cell, and a binary "zero" is recognized by a negative followed by a positive voltage pulse within a cell. "Ones" and "Zeros" are thus characterized by a 180 degree phase difference.

ADVANTAGES

1. ability to selectively alter (write) or read by bit.

RZ continued
2

ADVANTAGES -

2. less susceptible to noise produced by recording surface defects, due to neutral magnetization between bits.

3. does not require a lot of circuitry, about same as NRZI.

4. low average head writing current is realized due to a low-duty cycle.

5. self clocking, and self checking since two pulses always appear in every cell, (lack of signal is obviously an error).

6. "Ones" and "Zeros" can be recognized by a 180 degree phase difference, rather than amplitude.

DISADVANTAGES -

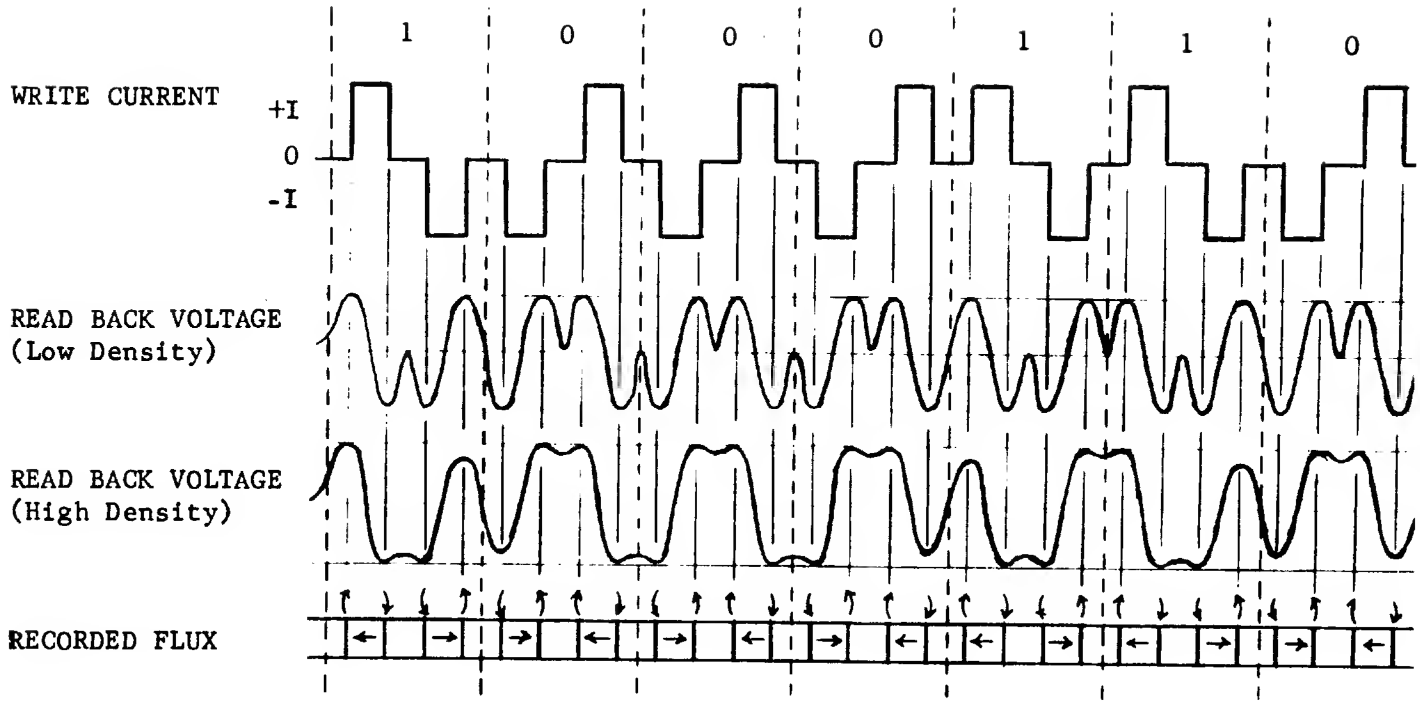
1. pulse packing density limit is less than that of NRZ and NRZI, since two flux changes (instead of one as for NRZI) are contained within a cell.

2. external means must be provided to pre-erase old information before recording new, if self-clocking system is employed. (Requires neutralization of medium between bits). Pre-erasing is generally not necessary if a clocking track is provided which identifies and fixes each cell position.

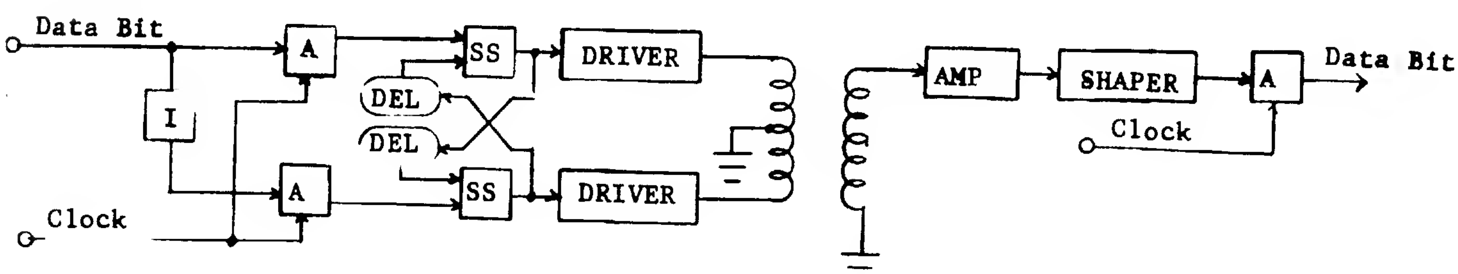
3. about 1/2 read amplitude of NRZ and NRZI because recording is from neutral to saturation rather than from saturation to opposite saturation.

DPRZ - Double Pulse Return to Zero

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a positive rectangular current pulse followed by a negative pulse one-half a cell-time later; and a binary "zero" is recorded by a negative current pulse followed by a positive pulse, one-half of a cell-time later. If pulse width is extended to one-half cell-time, DPRZ becomes identical to PM recording.



READ RECOGNITION OF BITS - A binary "one" is characterized by a negative going voltage cross-over followed by a positive going voltage cross-over one-half a cell-time later. A binary "zero" is characterized by positive going voltage cross-over followed by a negative going voltage cross-over one-half of a cell-time later.

ADVANTAGES -

1. It has been reported that an increase in bit resolution is obtained over the RZ method. With the RZ method, a string of "zeros" or "ones" closely packed together will result in enough flux crowding to merge play-back pulses resulting in a very low resolution. The DPRZ method, appears to compensate for this effect due to the appearance of oppositely polarized flux excursions within a group of "zeros" or "ones".

2. Reduction in average current flowing through head due to low duty cycle, which may be important if any dissipation or heating effects become a problem.

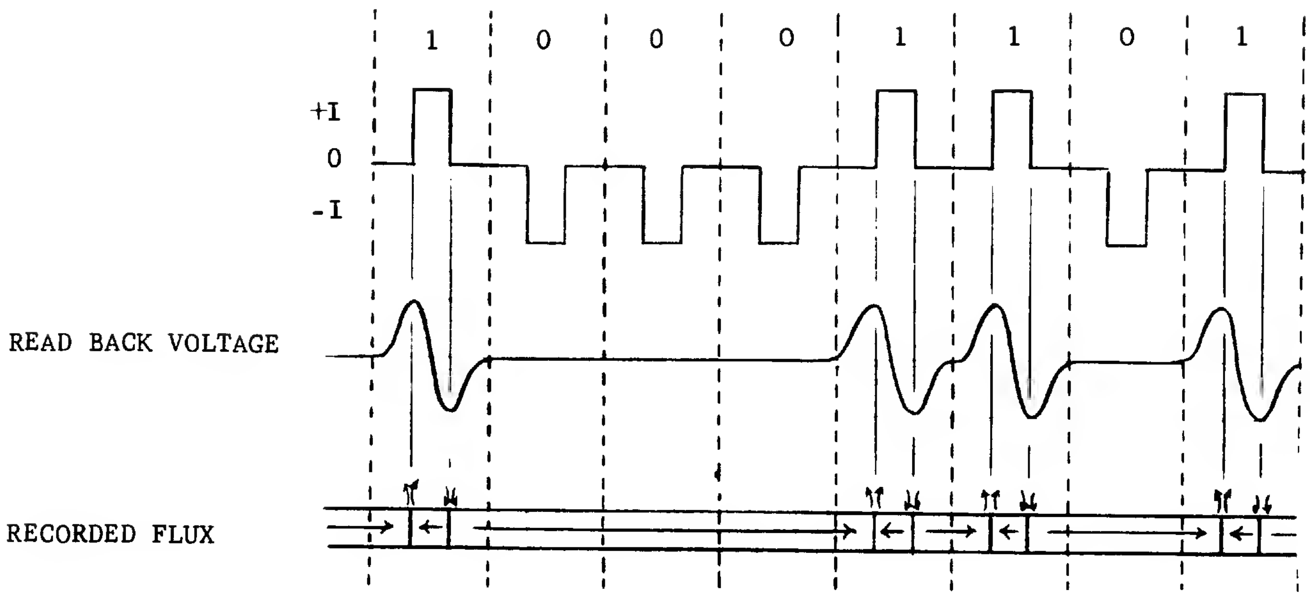
DISADVANTAGES -

1. Resolution or packing density limit is less than NRZI although it is greater than RZ.

2. The medium must be A.C. erased prior to recording if a self clocking system is employed. (requires neutralization between bits). Pre-erasing is generally not necessary if a clocking track is provided which identifies each cell position.

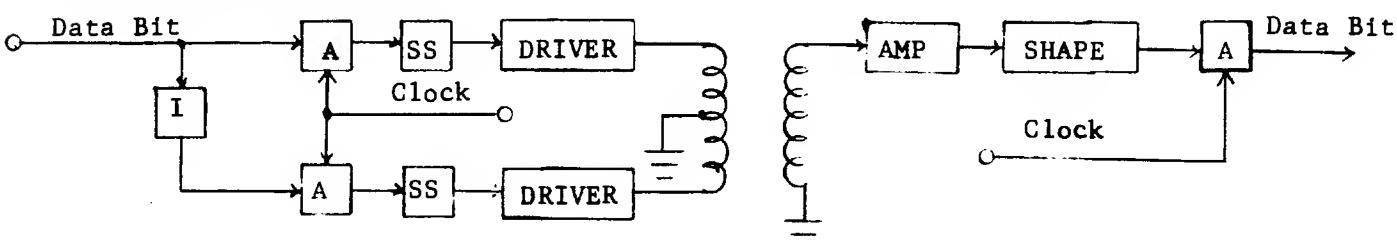
RZ-W/PB - Return to Zero with Pre-Bias (Pre-Biased Discrete Pulse Recording)

<u>Example</u>



<u>LOGICAL RULES FOR RECORDING</u> - A binary "one is recorded by a positive rectangular current pulse at the center of a cell; and a binary "zero" is recorded by a negative rectangular current pulse (or by the absence of a pulse at the center of a cell). Recording must be on a medium that is pre-biased to a negative saturation level.

<u>RECORD/PLAY-BACK LOGIC</u>



<u>READ BACK RECOGNITION</u> - Because the recording is on a medium pre-biased to a negative saturation, the negative pulses used for recording "Zeros" will not change the pre-bias state. Positive current pulses (representing "Ones"), however, will drive the medium to the positive state. Therefore during the process of reading back the information, "zeros" will be characterized by an absence of a pulse, while "ones" will be characterized by a positive followed by a negative voltage pulse within a cell.

ADVANTAGES -

1. The process of pre-bias or erasing is a little simpler than in the conventional RZ-method.
   Instead of erasing with high frequency erase current as with RZ, erasing can be done with either an electro magnet, permanent magnet or just another write head driven with a constant DC bias current.

2. The read-back signal smplitude is about twice that of RZ.

3. The read signal is always the same shape and contains the same basic frequency. This permits noise elimination by use of a narrow band bass amplifier.

DISADVANTAGES -

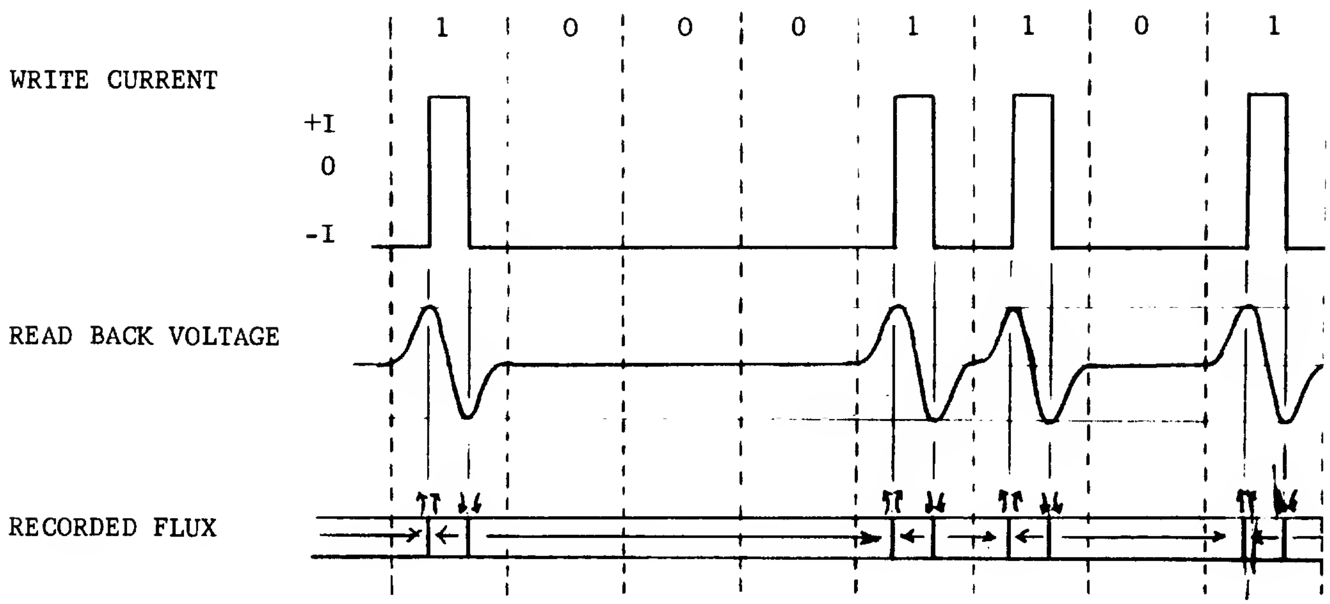
1. Pulse packing density limit is less than NRZI, since two flux changes are contained within a cell.

2. Differentiation between a drop-out and a "zero" is impossible unless a parity bit or other checks are used.

3. Read-back noise due to imperfections in the medium is at a maximum since the medium is saturated in the intervals between pulses. This effect, however, can be minimized by the use of high quality recording media.

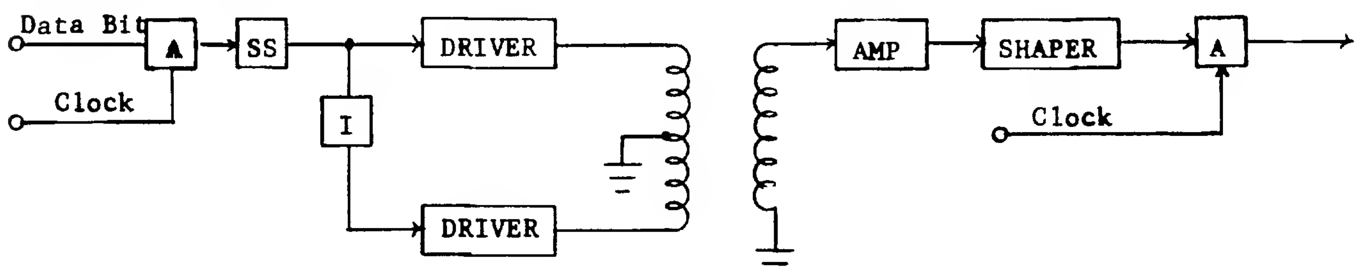
RTN - Return to Negative (Return to Saturation; Biased Discrete Pulse Recording)

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a positive rectangular current pulse at the center of a cell period, and a "zero" is recorded by the absence of a pulse. Write current is always returned to a negative level following the writing of a "one".

RECORD/PLAY-BACK LOGIC



READ BACK RECOGNITION OF BIT - Upon read back, "ones" will be represented by a positive followed by a negative voltage pulse within a cell period and "zeros" will be characterized by the absence of a pulse. This method is very similar to RZ-W/PB, since the same recorded flux and Read back voltage waveforms are obtained.

RTN
2

ADVANTAGES -

1. No pre-bias (Erase) operation is necessary since recording is done at saturation, excluding other factors.

2. The read-back signal amplitude is about twice that of RZ.

3. The read signal is always the same shape and contains the same basic frequency. This allows noise elimination by use of narrow bandpass amplifier.

DISADVANTAGES -

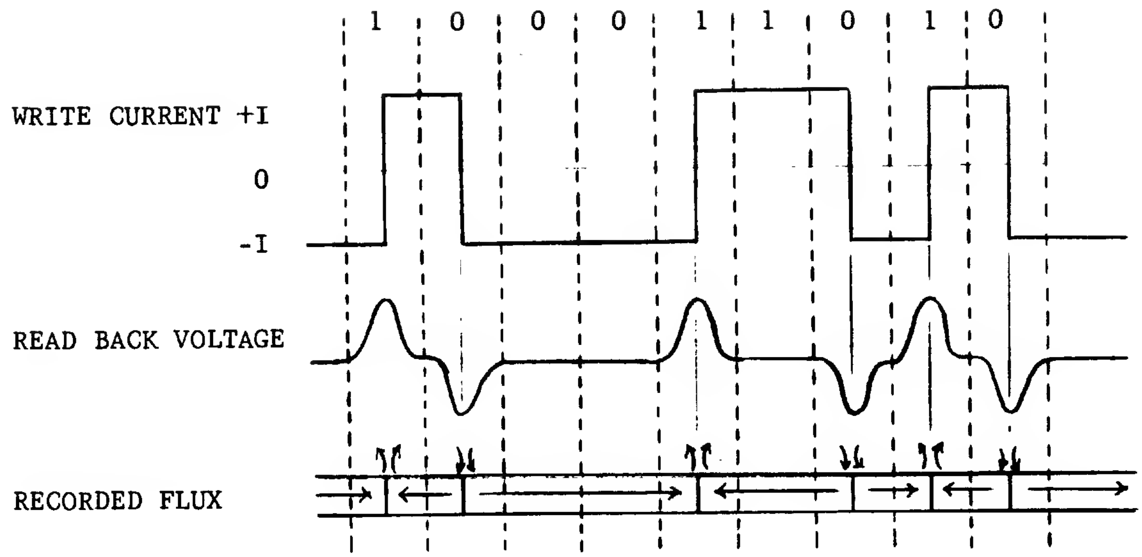
1. pulse packing density limit is less than NRZI, since two flux changes are contained within a cell.

2. differentiation between a drop-out and a "zero" is impossible unless a parity bit or other checks are used.

3. read-back noise due to imperfections in the medium is at a maximum since the medium is saturated in the intervals between pulses. This effect, however, can be minimized by the use of high quality recording media.

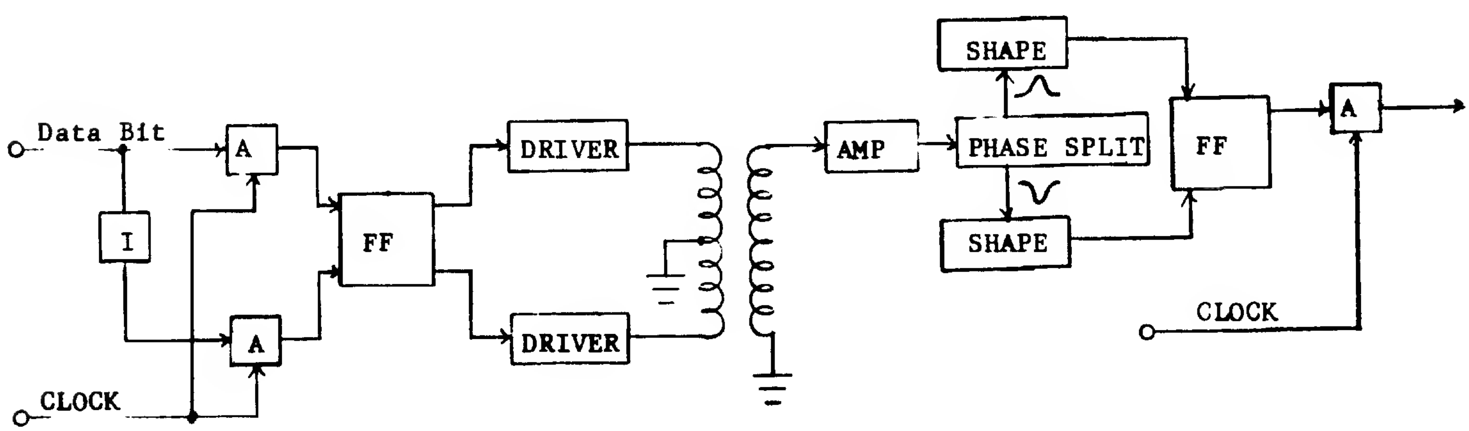
NRZ - Non Return to Zero

Example



LOGICAL-RULES FOR RECORDING - A binary "one" is recorded by a positive current throughout the entire bit period, and a binary "zero" is recorded by a negative current throughout the entire bit period.

RECORD/PLAY-BACK LOGIC



READ BACK RECOGNITION OF BITS - A "zero" cell followed by a "one" cell is characterized by a positive read-back pulse. A "one" cell followed by a "zero" cell is characterized, by a negative read-back pulse. A string of "ones" will be characterized by an initial positive pulse followed by the absence of a pulse for every "one" cell in that string; similarly a string of "zeros" will be characterized by an initial negative pulse followed by an absence of a pulse for every "zero" cell in that string.

NRZ
2

ADVANTAGES

1. The primary advantage of NRZ appears to be in realizing a high bit packing capability from any medium, since a maximum of only one flux change per bit is required.

2. Since recording is done at saturation, the medium need not be erased prior to recording, excluding other factors.

3. Read-back signal amplitude is about twice that of RZ.

DISADVANTAGES

1. The reading process is a little more complex since it is necessary for the reading circuit to remember the polarity of the first bit of a string of identical bits in order to identify these bits.

2. Some form of read clocking is necessary to determine when to sample for the presence or absence of a signal.
   An initial starting condition must be defined because the first string of bits in a record may be recorded at the same flux direction as the area before the record resulting in no initial pulse for that string.

3. Differentiation between a drop-out and an intentional lack of read signal is impossible unless a parity check or other checks are used. A drop out could result in a number of consecutive errors.

4. Read-back noise due to imperfections in medium is a maximum since the medium is saturated between pulses. This can be minimized by the use of high quality recording media.

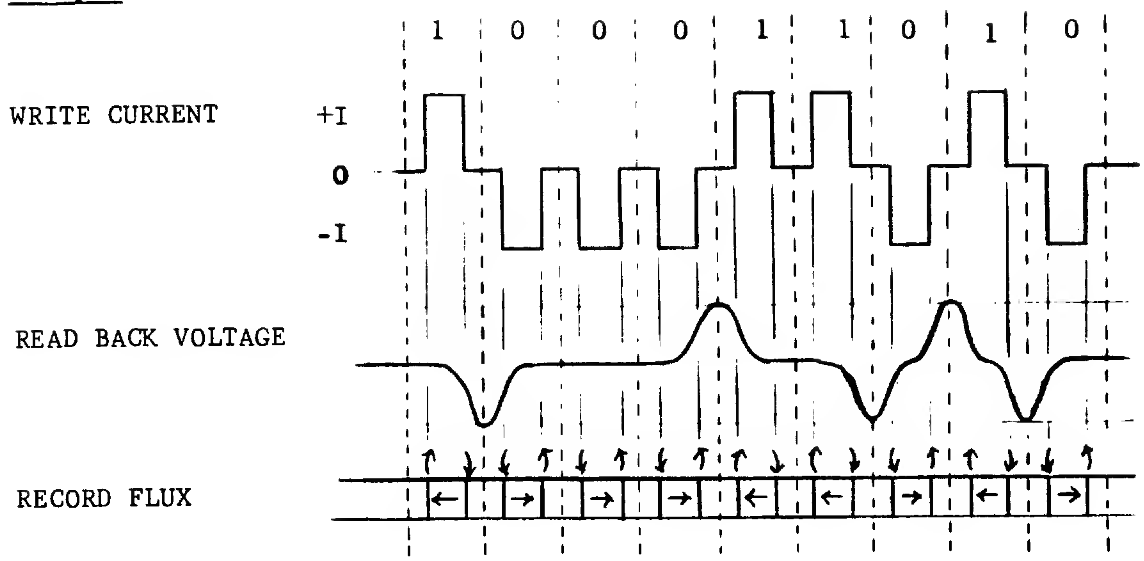
5. Requires higher power handling capability in Write Head and Write drivers than in the case of RZ, RZ-W/PB and DPRZ.

6. Read Amplifier must have wide requency range.

7. Requires a little more read circuitry than NRZI.

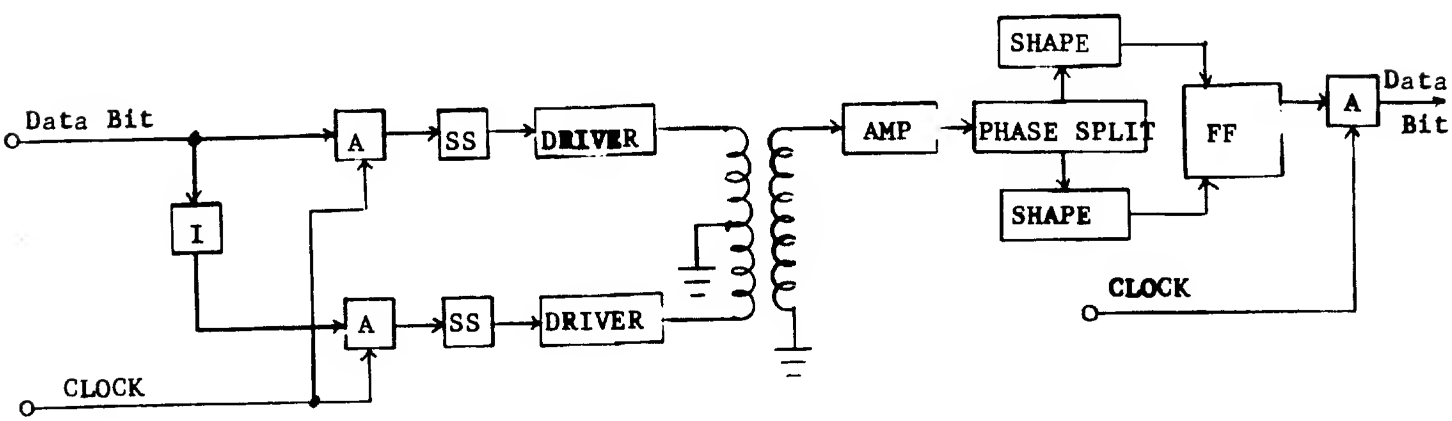
Pulse Envelope Recording

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a positive current pulse and a binary "zero" is recorded by a negative current pulse.

RECORD/PLAY-BACK LOGIC



READ BACK RECOGNITION OF BITS - In pulse-envelope recording, discrete pulses are recorded at such a high density that head resolution in both reading and writing causes only "one" to "zero" and "zero" to "one" changes to read-back. Thus the read-back is in the form of NRZ.

Pulse Envelope Recording
2

ADVANTAGES

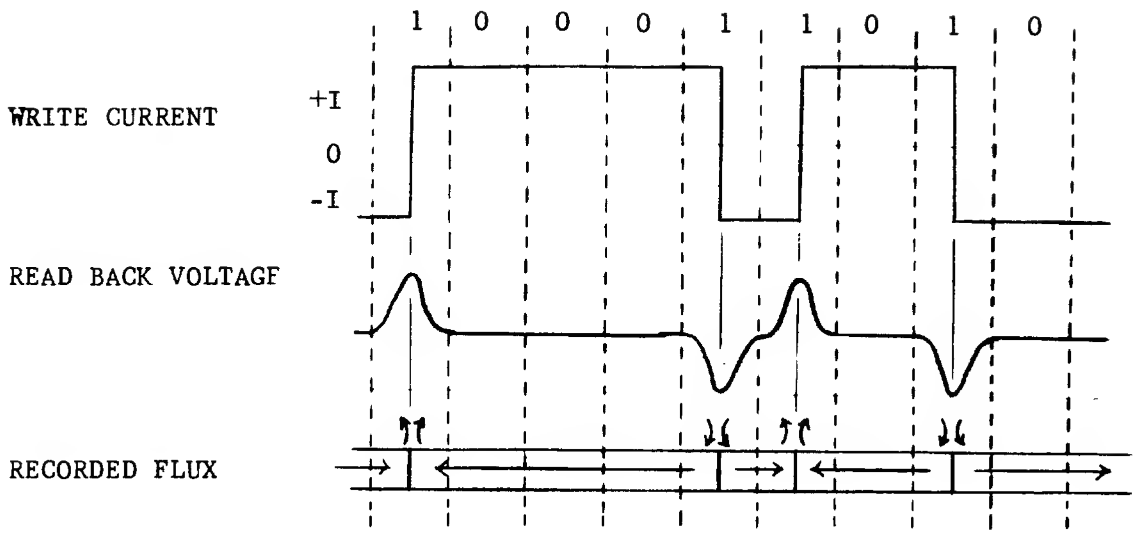
1. Lower duty-cycle than NRZ.

DISADVANTAGES

1. Double frequency requirements in the write circuits.

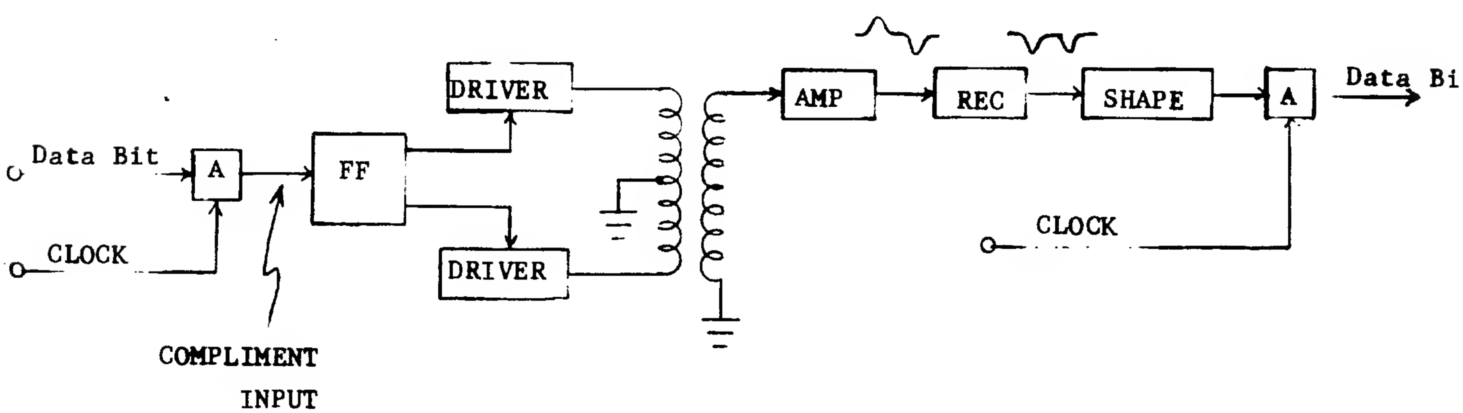
NRZI - Non Return to Zero Indiscrete (Pouliart's Variation)

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a reversal of current direction, and a binary "zero" is recorded by no reversal of current.

RECORD/PLAY-BACK LOGIC



READ BACK RECOGNITION OF BITS - Since a flux reversal occurs for every "one" written, only "ones" will appear as pulses, regardless of polarity. "Zeros" can only be identifed by the absence of a signal.

NRZI
2

ADVANTAGES

1. High bit packing capabilities can be realized since a maximum of only one flux change is required per bit.

2. Since recording is done at saturation, the medium need not be erased prior to recording, excluding other factors.

3. Simpler Read Back logic circuitry than NRZ.

4. Signal amplitude is about twice that of RZ methods.

5. A drop out during play-back will result in only one error rather than a string of errors which is possible with NRZ.

DISADVANTAGES

1. Not self clocking because information is recorded by the absence of a pulse during read-back. This requires use of a clock track or schemes using other tracks, or oscillators.

2. Impossible to differentiate between a drop out or intentional absence of a pulse without use of more elaborate checking schemes, eg. parity checking.

3. Read-back noise due to imperfections in medium are maximum since the medium is saturated between bits. This effect can be minimized by use of high quality recording media.

4. Requires greater power handling capability in write head and drivers than RZ methods.

5. Read amplifier must handle a wide range of frequencies.

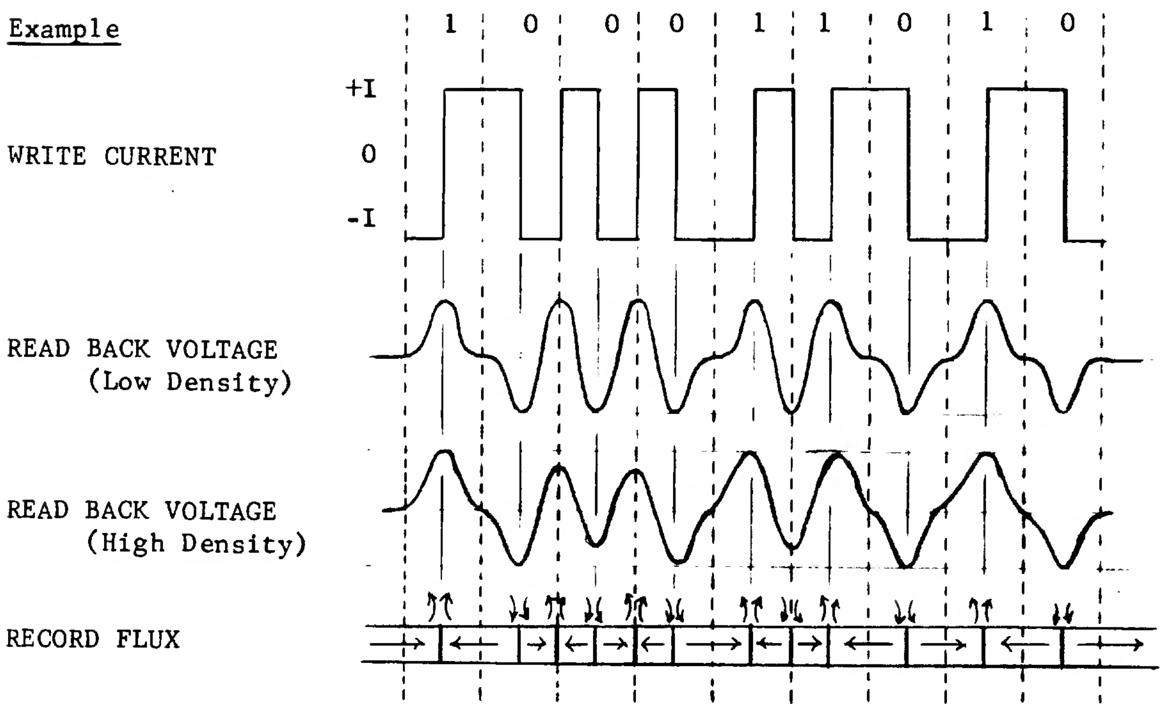
USES

1. Most Computer Magnetic Tape Applications.

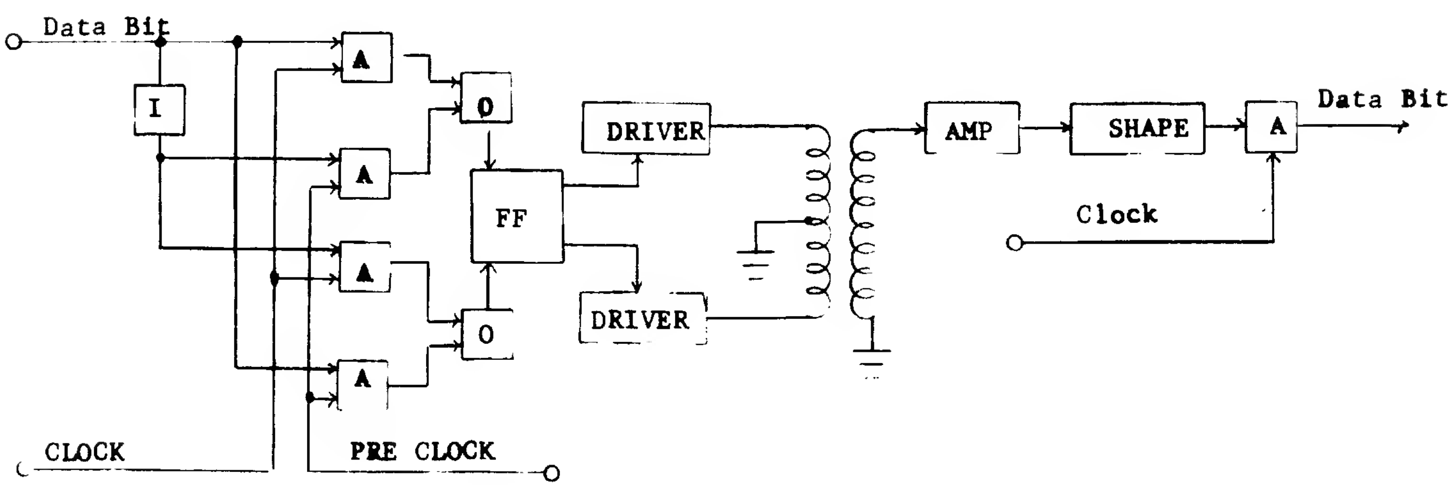
2. Some Disk File Applications, eg. IBM 1311 Disk Pack.

PM - Phase Modulation (MNRZ-Modified Non Return to Zero; William's Phase Modulation; Manchester Recording; Double Transition; Ferranti Recording).

Example



RECORD/PLAY-BACK LOGIC



PM
2

LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a positive current change; and a binary "zero" is recorded by a negative current change. This necessitates a negative current change between consecutive "on" cells and a positive current change between consecutive "zero" cells.

READ BACK RECOGNITION OF BITS - A binary "one" is identified by a positive pulse at the center of a cell, and a binary "zero" is identified by a negative pulse at the center of a cell.

In addition, other characteristics of the read-back signal are apparent upon examination of the waveform. These are:

a) A positive pulse at the junction of two cells indicates that both cells contain "zeros". Conversely a negative pulse at the junction of two cells indicates that both cells contain "ones".

b) The absence of a pulse at the junction of two cells indicates that the cells contain opposite binary bit values.

Thus, the presence or absence of a pulse at the junction of two cells not only can predict the succeeding binary bit but also serves as a checking feature on a bit by bit basis.

ADVANTAGES

1. Clocking and checking may be simplified since a pulse always appears at the center of a cell.

2. The binary bit can be identified by polarity rather than amplitude.

3. The frequency response requirement of the over-all Record/Play-Back System is relaxed somewhat because of the maximum flux to transition period of two to one. (i.e. limited to one octave).

4. The medium need not be erased prior to writing, excluding other factors.

5. Signal amplitude is about twice that of RZ methods.

6. Theoretical effective signal amplitude is twice that of NRZI. This is due to the fact that both "ones" and "zeros" are recorded, and the difference between a "one" and a "zero" is twice as large at strobe time during read back. This implies a signal-to-noise ratio of 2:1 in favor of PM over NRZI as long as the density is one-half NRZI.

ADVANTAGES

7. Higher bit densities than NRZI (1.5 times maximum NRZI) are possible at the expense of signal-to-noise ratio.

DISADVANTAGES

1. Write circuitry is about twice as complex as NRZI.

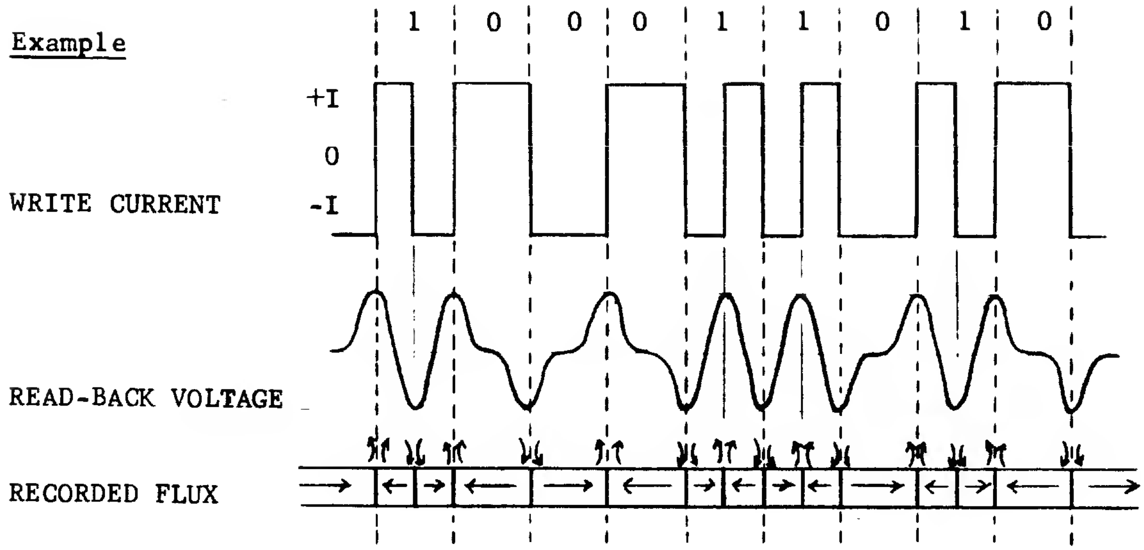
2. Large signal amplitude variations encountered when reading at densities near or beyond maximum possible NRZI density.

3. Read back noise due to imperfections in the medium are maximum since the medium is always saturated. This effect can be minimized by use of high quality recording media.

4. Requires greater power handling capability in write drivers and head than RZ methods.

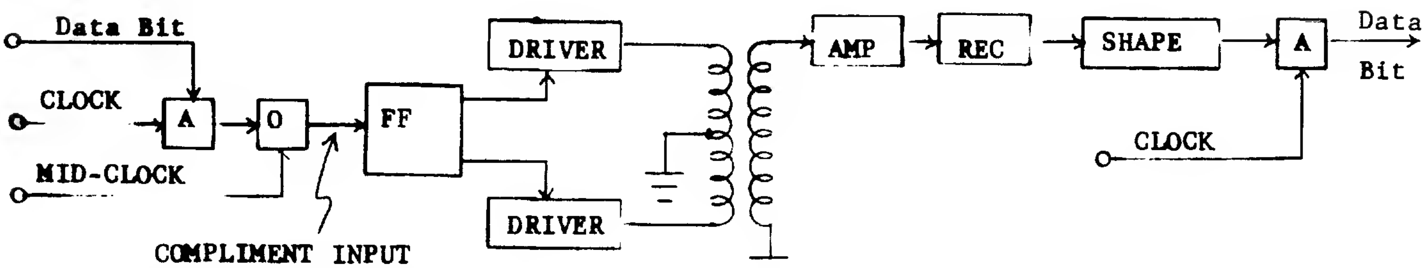
FM - Frequency Modulation (Freq. Shift)

Example



LOGICAL RULES FOR RECORDING - A binary "one" is recorded by a reversal of current at the center of a cell, and a binary "zero" is recorded by a constant polarity of current for the entire cell period. There is always a current reversal at the beginning and end of each cell.

RECORD/PLAY-BACK LOGIC



READ-BACK RECOGNITION OF BITS - A binary "one" is identified by two pulses occuring during a cell period, and a binary "zero" is identified by only one pulse occuring during a cell period.

A binary bit can also be identified by strobing the pulse polarity at the end of each cell period, and comparing it to the polarity at the end of the previous cell; similiar results indicate a stored "one" and dis-similar results indicate a stored "zero".

FM
2

ADVANTAGES

1. Clocking and checking can be simplified since a pulse (either positive or negative) will always appear at each cell junction.

2. The frequency response requirement of the overall Record/Play-Back system is relaxed somewhat because of the maximum to minimum flux transition period of 2 to 1 (ie. limited to one octave).

3. The medium need not be erased prior to writing since the surface is always saturated by the write head. This excludes other factors which might dictate erasing.

4. Signal Amplitude is about twice that of RZ methods.

5. Does not require as much write circuitry as PM.

DISADVANTAGES

1. Requires more complex write and read circuitry than most other methods.

2. Large signal amplitude variations encountered when reading at densities approaching maximum possible NRZI density.

3. Pulse polarity has no relation to the value of a bit. Therefore FM would have half the effective signal to noise ratio of PM. This limits the bit density to some value less than PM.

4. Read-back noise due to imperfections in medium are maximum since the medium is always saturated. This effect can be minimized by use of high quality recording media.

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